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HERBERTIA

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HERBERTIA

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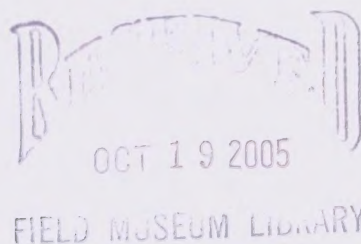
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EDITOR'S NOTES

We have been heartened this year by a sizable number of new members of IBS. To them I bid a warm welcome, and to those contributors of financial gifts to the society, deep gratitude.

IBS added a new board member this year in Michael Loos, who will be helping to grow IBS as Director of Publicity and Development. Your board welcomes Michael and looks forward to his proposals for helping increase our financial stability as well as membership.

The International Bulb Society is entering into an agreement with EBSCO, a scientific journal distributor and online access service that, will allow EBSCO to offer our publications within an online package of related journals. We think that this will increase exposure for IBS.

Congratulations to our Herbert Medalist for 2003, Dr. Harold Koopowitz. Harold is no stranger to most of the IBS membership, and it is an honor well deserved. Harold's books occupy a prominent place on most of our bookshelves. And kudos to Dave Lehmler, who receives the Traub Award for 2003. Dave's meritorious service to IBS is detailed further in this volume.

Again, our year labeling of this volume reflects the two-year citation we began last year. Members paid up through 2003 will receive this volume. Volume 59 will be dated 2004-2005, and will be mailed to all members who have paid their dues through 2004.

Please note that the final deadline for submissions for volume 59 (2004-2005) of HERBERTIA is December 1, 2005.

—Alan W. Meerow, Editor

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THE HERBERT MEDAL



The Herbert Medal is the highest honor that the International Bulb Society can bestow upon a person for meritorious achievement in advancing the knowledge of bulbous plants. The medal is named for William Herbert (1778-1847), son of Henry Herbert, Earl of Carnarvon. William Herbert had a predilection for amaryllids and achieved success in their hybridization. He published his research findings in several monumental works. His contributions as a pioneer geneticist and plant breeder, and his arrangement of the Amaryllidaceae, helped set the stage upon which other workers, both amateur and professional, have been able to advance.

The award includes honorary life membership in the Society.

The Herbert Medal may be awarded annually or on special occasions by the Board of Directors of the Society. Medalists need not be members of the Society to be considered for the Herbert Medal.

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Mr. Fred Meyer, California, 1999

Dr. Peter Goldblatt, Oregon, 1999

Dr. August DeHertogh, North Carolina, 2000

Dr. David Lehmiller, Texas, 2000

Graham D. Duncan, Capetown SA, 2001

Dr. Marcel Le Nard, France, 2002

2003 HERBERT MEDALIST HAROLD KOOPOWITZ



I was born in the city of East London in South Africa after the beginning of the Second World War, the child of an American mother and South African Father. My earliest memories concerned the plants in our garden and begging my mother to buy seeds and plants. At that stage I must have been 3 to 4 years old. As soon as it was safe to cross the Atlantic we returned to America and I started kindergarten in San Francisco. At about the age of 5, when I had my tonsils removed, I was given a pink hyacinth in the

Hospital as a get well present. Actually I was rather disappointed, as I had requested tulips instead. I think the other kids were probably asking for ice cream. My mother had close friends who were great gardeners and it was always a treat to visit them as I usually returned home with a tuberous begonia or pot of grape hyacinths or some other encouragement.

We returned to South Africa and settled in a small village called Queenstown. It was a mountainous region and I spent most of my childhood roaming the veldt, collecting plants, which ended up in our large garden. I collected succulents and bulbous plants. It was a wonderful place for a child interested in nature. *Moraeas* and *drimias* were sidewalk weeds and *Crinum macowanii* flaunted its flowers every summer under the thorn trees at the edge of town.

Each fall the small local nurseries sold bulbs, imported from Holland that had been stored to delay their emergence an additional six months until the African spring. By the time I was ten, I had accumulated all the daffodils and hyacinths available—not very many but enough to whet my appetite. After several years I no longer wasted my meager pocket money on crocus or tulips. They never did perform, but the narcissus were always reliable.

I had made up my mind before the age of ten that my career would have something to do with animals or plants, either a nurseryman or farmer of some sort. Our family doctor had other ideas and one day he said to me, “Harold, you need to go to the university and get a bachelor’s degree and then a masters and a doctorate and then you will become a professor” and

so I did. My undergraduate work and the master's degree were earned at Rhodes University in South Africa. One of the great problems in my life was choosing whether to specialize in the plant or animal sciences. I majored in both botany and zoology. Discussing my future with the professor of zoology at Rhodes he advised that I do Plant Sciences. I asked why and he said that he did not think that I had the ability to master animal physiology. Unable to resist this challenge I insisted on zoology and in the end worked with the same professor.

Apartheid was at its peak in South Africa at that time and I found the system unconscionable. I had dual citizenship in those days and decided that I would return to California to live. I came to the University of California at Los Angeles, specializing in Invertebrate Neurophysiology for my doctorate, but I managed to sneak in a few botany courses at the same time. In the late 1960s the University of California was in an expansion phase and the new campus at UC Irvine needed someone to teach invertebrate zoology. I was offered the job though I had not yet completed my Ph.D. I rushed through the thesis and moved down to Orange County in the fall of 1968. I married a New Zealander in 1969, and our first child (a daughter) was born a year later; a son followed a few years later.

As a young married couple one of our fun things was to grow pots of hyacinths for all of our friends as Easter gifts. We did this for many years and we started to buy our hyacinths directly from Holland. The first Dutch shipment contained a gratis bulb. It was the daffodil 'Newcastle'. Little did I know then that this gift would change my life. When the 'Newcastle' flowered I was totally smitten. This was so superior to any of the daffodils of my childhood that I immediately started to collect daffodils and then started breeding them. Local members of the Southern California daffodil Society were generous with their bulbs and advice. Before long I had totally exhausted all of the garden space in our small plot. I needed more room!

The Directorship for the UCI Arboretum became vacant in the mid 1970s and I applied for and was appointed to that position. The facility was 13 acres, and the one perk would be room to grow my daffodil seedlings. There was no salary for the director and I would still have to fill all my professorial duties. The arboretum was really a botanical garden and possessed almost no trees. I needed to find something unique to do with the garden that would also have enough pizzazz to attract funding. Biodiversity conservation was just getting off the ground at that time. I started one of the first gene banks for wild flowers, writing a lot of proposals. This garnered a great

deal of publicity and we were soon able to generate sufficient funding to staff the garden. At first the focus was on the genus *Gladiolus* and we tried to assemble all the species. Fortunately, there were good seed sources in South Africa and the collection started to grow. We also set up a seed bank where seed was stored at -40°C . We then collected close relatives of *Gladiolus* and eventually anything in the family Iridaceae. The collection was expanded to anything that was an African geophytic, petaloid monocot. From this we then went to adding European and South American bulbous and cormous plants. After exhausting the known seed sources, the Arboretum mounted its own seed-collecting expeditions into Africa. We traveled repeatedly to Africa, visiting Malawi, Zimbabwe and South Africa. At its peak in the early 1990's, we had over 10,000 living accessions, an accession being anything from a single plant to over a thousand bulbs. The Arboretum started to attract horticulturalists from around the world and we found we had developed an international reputation.

With all the special germplasm we had accumulated it was only natural to try and use some of it for producing garden plants. The arboretum had extensive breeding and hybridizing programs in *Cyrtanthus*, *Gladiolus* and *Ornithogalum*. The results of some of this work were published in **Herbertia**.

In 1992, the Arboretum and IBS co-hosted an International Bulb Symposium where we brought together serious amateurs, botanists and commercial growers. It was a great success and the papers were published in **Herbertia**. Many people contributed to the success of the symposium, but the late Fred Meyer was perhaps the principal benefactor. This conference helped to focus attention on African bulbous and cormous plants, but we were also able to bring the concerns of the conservation community to Dutch commercial interests. One outcome was the label on autumn bulb packages proclaiming that the contents are from cultivated materials. Following the symposium, the International Bulb Society entered one of its transition stages and I became involved in its reorganization.

In 1983, my book *Plant Extinctions—a Global Crisis* was published. This was one of the first books ever to discuss plant conservation aimed at the non-specialist. Written with Hilary Kaye, a journalist at the University, it was a success and over the years was translated into a number of languages.

By the mid 1980s, I started to attract students interested in conservation and plant ecology so I switched over and became a plant ecologist, teaching courses in Conservation Biology as well as Flowering Plant Taxonomy. I

became interested in orchids, especially slipper orchids, and together with Norito Hasegawa started breeding them commercially. We also wrote a book on *Novelty Slipper Orchids*. As part of a long-term project, I started to study *Aerangis verdickii*, an orchid from Zimbabwe, and spent several seasons doing research in that country.

I retired from the Arboretum directorship in 1996 but have continued as a professor at UCI, teaching, conducting research and writing. I still breed daffodils. I still travel extensively, most recently in Southern Spain observing pollination in *Narcissus serotinus*, and in South Africa doing research for a book on *Clivia*, which was published by Timber Press in 2002.

I have been very lucky in my life; blessed with many friends, opportunities to travel and beautiful flowers. What more could one want?

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HIERONYMIELLA (AMARYLLIDACEAE),
A LITTLE KNOWN GENUS FROM ARGENTINA AND BOLIVIA

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SUMMARY

A short survey of the history of the southern South American genus *Hieronymiella* (Amaryllidaceae) is given and the results of a taxonomic revision based on herbarium studies and field observations are presented. It includes a brief description of the genus, a key to the species, distribution map, typification of names, synonyms, diagnostic characters of species, and citation of selected specimens studied. Some observations are made on the habitat, ecology, and phenology. Three species are illustrated by photographs.

INTRODUCTION

Hieronymiella is a small genus of Amaryllidaceae established in 1890 by the German botanist Ferdinand Pax based on a herbarium specimen of a plant collected by Paul Lorentz in 1872 in the Province of Catamarca, Argentina. For several decades, the circumscription of the genus remained poorly understood, controversial, and its range insufficiently known. A total of 13 species names have been attributed to the genus. Seven were described as new species under this genus name, five of these by Ravenna (1967, 2000, 2001a, 2001b), most based on a single collection. Six were transferred from other genera, namely from *Eustephia*, *Eustephiopsis*, and *Androstephanos*. The last two genera are synonyms of *Hieronymiella*.

According to published sources (Hunziker, 1975; Arroyo-Leuenberger and Hunziker, 1995; Arroyo-Leuenberger, 1997) as well as a still preliminary revision by the first author, *Hieronymiella* today contains only five well-delimited and uncontroversial species. Six names are listed as synonyms. One is discussed as a probable synonym of *H. marginata*. One name is considered to be dubious. The geographical range of the genus is on the eastern flank of the Andes, mainly in north-western Argentina, with only one species extending into southern Bolivia.

The purpose of this paper is to give a brief survey of the history as well as a critical synopsis of the known taxa with representative illustrations of

selected species. It is based on research in the herbarium, observations in the field during several journeys to north-western Argentina made between 1994 and 2003 and on a few cultivated specimens of three species.

TAXONOMIC HISTORY AND THE HISTORY OF BOTANY IN ARGENTINA

In the second half of the 19th century, the scientific development of Argentina was strongly influenced by the minister and later president Domingo F. Sarmiento and by the influential director of the natural history museum of Buenos Aires, Hermann Burmeister, a German immigrant. Several scientists from Germany were appointed as professors to the newly founded Academy of Science at Córdoba in central Argentina, which became the major academic institution outside of Buenos Aires. Paul Lorentz and his assistant and successor Georg Hieronymus became well known for their botanical explorations and phytogeographical studies. Hieronymus was accompanied in some travels by another German, Gustav Niederlein, and stimulated the chemist Friedrich Schickendantz to collect plants in remote mining areas of Catamarca and Tucumán. The majority of these herbarium specimens were deposited in the Museum at Córdoba; some collections, often whole sets of duplicates, were sent to the Botanical Museum Berlin and to Göttingen for identification. They became the base for the "Plantae Lorentzianae" and "Symbolae ad Floram Argentinam" of Grisebach (1874, 1879). These represent the first floristic studies on Argentina, at that time still a little explored country botanically. In the first paper, Grisebach (1874) mentioned a plant collected by Lorentz in Catamarca, identified as *Chlidanthus fragrans* Herbert. In 1879 he cited the same again with a modified spelling as "*Clidanthus*." Baker (1888) uncritically repeated this report. *Chlidanthus fragrans* is a species originally described from Peru.

When Pax, colleague and friend of Hieronymus and, from 1889 to 1893, assistant of Adolf Engler in Berlin, revised collections of Amaryllidaceae from Argentina, he recognized the misidentification, most likely due to the *Chlidanthus*-like, long-tubed flowers of the plant from Catamarca. Analysing flower structure, he determined that Lorentz's specimen represented a new genus. He named it *Hieronymiella*, explicitly dedicating it to his highly revered friend Hieronymus, honouring his contributions to the flora of Argentina, the country of origin of the new plant. Alluding to the similarity of the plant to another genus, he aptly named the species *Hieronymiella clidanthoides*, i.e., resembling a *Chlidanthus*. Pax (1890)

distinguished *Hieronymiella* from related genera (*Eustephia*) by the broadened, apically winged filaments with horn-like appendages. In the same paper, he described two new species of *Eustephia* (*E. argentina* and *E. marginata*) with tubular flowers, one based on a collection of Schickendantz and one from Hieronymus and Niederlein. Roughly a century later, after a re-evaluation of generic characters and with more collections and data available, these two names, which also belong to species with apically winged and fused filaments with horn like-appendages, are today considered to belong to *Hieronymiella* as well (Hunziker, 1969; Arroyo-Leuenberger and Hunziker, 1995). However, for the first decades following its description by Pax, the genus remained monotypic.

The Swedish botanist R. E. Fries worked on new collections from Jujuy, the most botanically diverse province of Argentina. This included material from his own extensive field trips (1901-1902) and herbarium specimens contributed by others (namely the collectors Claren and Hofsten). Among many other new species, Fries recognized two new taxa, which he considered to be different from *Eustephia* and *Stenomesson*. He failed to relate them to *Hieronymiella*. He created the new genus *Eustephiopsis*, based on the winged and partially united filaments (Fries, 1905). Studying the type material of *Eustephia marginata*, he realized that this species also had partially united filaments. Thus, he included it as a third species in *Eustephiopsis*. He suspected that *Eustephia argentina* belonged there as well, but stated that he did not have access to material of this taxon.

It needs to be taken in account that these authors had a very limited number of herbarium specimens for study. These few specimens were dispersed among different herbaria, and live plants were not available for study. For many decades this situation persisted, and no overall revision based on ample material was possible.

Eustephia pamiana Stapf (1927) is the first example of a species now treated under *Hieronymiella* that was described from a flowering bulb in cultivation. Although Stapf was aware of the characters discussed by Fries (1905), he apparently overlooked the presence of the partial fusion of the filaments in the new species. It was included in *Hieronymiella* only half a century later by Hunziker (1975). The Argentinean botanist Castellanos (1935), who travelled widely in western and north-western Argentina, observed that the filaments were also partially fused in material of *Hieronymiella clidanthoides*. He corrected the generic description of *Hieronymiella* but did not relate his observation with the distinguishing

character of *Eustephiopsis*. Thirty years later, Amaryllidaceae became again a focus of interest in Córdoba, the same place where Lorentz and Hieronymus had worked. Armando Hunziker, university teacher, researcher and collector, editor of the “genera of phanerogams of Argentina” (Hunziker, 1984) and specialist in Solanaceae (Hunziker, 2001), systematically collected bulbous plants in central and north-western Argentina. He accumulated numerous herbarium collections and also cultivated some specimens. As a result, several papers on *Hieronymiella* and other Amaryllidaceae appeared. This generated new interest in this group. Hunziker (1967) published a strikingly new, yellow-flowered species, *Hieronymiella tintinensis*, providing a detailed description and an excellent illustration in ink. The plant had been collected in 1965 in the province of Salta and flowered in cultivation at Córdoba. At the same time, Ravenna found material belonging to the same species in the herbarium at La Plata, collected decades before by Spegazzini, and rushed to publish it with a very brief diagnosis under the name *Hieronymiella aurea* Ravenna (1967). Ravenna’s name antedates Hunziker’s *H. tintinensis* by two months and thus has priority, notwithstanding the shortcomings of the publication. This prompted Hunziker (1969) to comment on the case and to publish a detailed synopsis of the genus, accepting four species, in which he maintained his own name, *H. tintinensis*. Hunziker (1969) grouped the species in two sections: *Hieronymiella*, for *H. clidanthoides*, and *Eustephiopsis*, comprising all other species.

Fernández Casas and Rico Lara (1983) described a purported novelty from Tarija, southern Bolivia, as *Androstephanos tarijensis*, emphasizing the presence of a corona above the apically united filaments as a generic character. This taxon was later recognized by Arroyo-Leuenberger and Hunziker (1995) as identical to *Eustephia argentina* Pax, and in fact a member of the genus *Hieronymiella*. The new combination *Hieronymiella argentina* was made and *Androstephanos tarijensis* included as a synonym.

This extended the range of this species and, consequently of the genus (originally considered endemic to Argentina), to Bolivia. Phytogeographically, this part of Bolivia shares characteristics described by Cabrera (1994) for the Prepuna region of Argentina.

Ravenna (2000) accepted the inclusion of *Eustephiopsis* in *Hieronymiella* as proposed by Hunziker (1969), described three new species, and proposed a new infrageneric treatment containing three sections: *Hieronymiella* (*H. aurea*, *H. clidanthoides*), *Eustephiopsis* (*H. speciosa*), and *Synexa* (*H. angacoana*, *H. argentina*, *H. ferruginea*, *H. latifolia*, *H. marginata* and *H.*

pamiana). One year later, he described two new species (*H. vittata* and *H. angustissima*) and, as a consequence of intermediate characters observed in *H. vittata*, reduced the sections to two: *Hieronymiella* (incl. *Eustephiopsis*), and *Synexa* (Ravenna 2001a, 2001b).

***HIERONYMIELLA* AND ITS CLOSEST RELATIVES**

When Pax (1890) established the genus *Hieronymiella*, he noted its relationship to *Eustephia*. Morphological evidence confirmed by molecular data permit classification of *Hieronymiella* together with *Eustephia* and *Chlidanthus* in the tribe Eustephieae (Meerow 1995; Meerow and Snijman 1998; Meerow et al., 2000a, 2000b).

The following key gives the diagnostic flower characters separating the three genera:

- 1a. Stamens with filaments apically winged and connate, the wing forming tooth or horn like prolongations at or below the point of attachment of the anther *Hieronymiella*
- 1b. Stamens with filaments free or connate at the base only, filiform, broadly subulate, or winged.
 - 2a. Flower funnelform or tubular-funnelform, the tube as long or longer than the free part of the tepals. Filaments subulate, free or very shortly connate at the base *Chlidanthus*
 - 2b. Flower tubular, tube much shorter than the free part of the tepals. Filaments free or connate at the base, the free part winged *Eustephia*

THE GENUS AND ITS SPECIES

The five fully accepted species are listed alphabetically and numbered, the species under observation is listed below the species of its probable affiliation. Doubtful names are discussed at the end.

***Hieronymiella* Pax.** Bot. Jahrb. Syst. 11: 327 (1890). Type: *Hieronymiella clidanthoides* Pax.

Eustephiopsis R. E. Fries. Nov. Act. Reg. Soc. Upsal. ser. 4, 1(1): 162 (1905).

Androstephanos Fern. Casas and R. Lara. Fontqueria 4: 33-36, f. 1 (1983).

Bulbous perennial plant. Bulb 3-8 cm diam., tunicate, sub-globose, globose to ovoid. Leaves appearing before the inflorescence, few to c. 8, distichous; lamina linear, channelled; margin smooth or finely scabrous-cartilaginous. Inflorescence scapose, scape solid, compressed, terminating in an umbel, 1-18(-20)-flowered, surrounded by two persistent, free bracts.

Flowers pedicellate to nearly sessile, suberect to declinate; perigone actinomorphic, funnellform or tubular, white, yellow, rose, or of various shades of red to orange-red, sometimes fragrant; tube short to long; tepals obovate to narrowly obovate, the outer tepals apiculate. Stamens 6, filaments inserted in the throat of the tube, free below, flattened, apically winged and connate into a short tube to narrow funnel, the wings prolonged into rounded or horn-like teeth; apical, free part of filaments filiform, up 0–7 mm long. Style straight; stigma trifid, 3-lobed, or capitate. Capsule 3-loculicidal. Seeds numerous, flattened, D-shaped; testa smooth, black. $2n = 42, 54, 56, 60$.

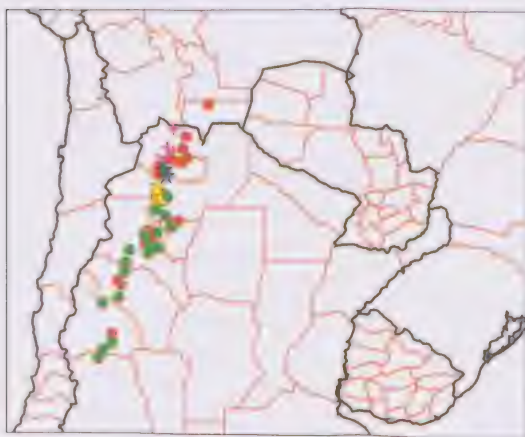


Fig. 1. Map of documented distribution of species of *Hieronymiella*. Explanation of symbols: *H. aurea* (yellow squares); *H. clidanthoides* (green dots); *H. marginata* (red dots); *H. speciosa* (purple crosses); *H. vittata* (blue stars). Map base: ArcGIS 8, ESRI Environmental Systems Research Institute Inc.

DISTRIBUTION AND ECOLOGY (FIG. 1)

On the eastern flank of the Andes and inter-Andean valleys, ca. 21°–ca. 32° S latitude, in southern Bolivia (Department of Tarija, Prov. O'Connor) and northwestern to western Argentina (Prov. Jujuy, Salta, Tucumán, Catamarca, La Rioja, San Juan, and northern Mendoza).

All *Hieronymiella* species are found in semi-arid to

arid habitats within phytogeographical zones (provinces) defined by Cabrera (1994): "Prepuna", the lower part of the "Puna", with one species in the northernmost part of the "Monte." The Prepuna is situated between the Chaco lowland in the east and the Puna (high Andean region) in the west, mostly in the rain shadow of the first high elevations which block the winter rains. The area receives rain fall irregularly, mainly in summer. Some typical precipitation totals are 175 mm for the "Prepuna" (in Humahuaca, Jujuy), 250 mm for the "Puna" (in Abra Pampa, Jujuy), and 173 mm (in Tinogasta, Catamarca) and 225 mm (in Chilecito, La Rioja) for the "Monte" (Cabrera 1994).

The bulbs are variously deep-seated, rarely superficial, depending on the substrate. The neck length was found to be long (to 30 cm), particularly where soil accumulates. The outer bulb sheaths are dry, brown-papery.

No direct observations on floral biology and seed dispersal have been made. Floral syndromes strongly suggest insect and bird pollination. Flower shape and scent in *H. clidanthoides* are characteristic for flowers visited by sphingid moths, and shape and color in *H. marginata* for hummingbirds. The corona-like structure formed by the filament wings could be interpreted as an adaptation to prevent easy access to the nectaries. The accrescent peduncles, widely opening capsules and flat, thin seeds facilitate seed dispersal by wind.

Phenological data from the field are available only from herbarium collections, not from continuous observations. Hieronymiellas flower in spring and summer in the southern hemisphere. Dates recorded are between October and February, few in September, very exceptionally at earlier times. In cultivation in the northern hemisphere, under glasshouse conditions at more than 52° N latitude in Berlin, plants of three species flowered in late May to mid July, i.e., at times seasonally corresponding to those on the southern hemisphere.

KEY TO THE SPECIES OF *HIERONYMIELLA*:

- 1a. Perigone tube longer than 5 cm, equal to much longer than the free part of the tepal segments.....2. *H. clidanthoides*
- 1b. Perigone tube less than 2,5 cm, much shorter than the free part of the tepal segments.
 - 2a. Flowers yellow. Filaments connate for 3 to 5 cm.....1. *H. aurea*
 - 2b. Flowers of various shades of red, orange-red, red and green, light rose, or white. Filaments only shortly connate (for less than 1 cm).
 - 3a. Flowers tubular, color variable from red, orange-red to light rose or partly greenish. Stigma capitate to 3-lobed. Leaf margin finely cartilaginous-scabrous3. *H. marginata* (incl. *H. pamiana*)
 - 3b. Flowers funnel-shaped, white with fine pink striation. Stigma trifid. Leaf margin smooth.
 - 4a. Plant in flower 5-8 cm high; scape 1(-3)-flowered4. *H. speciosa*
 - 4a. Plant in flower 25-40 cm high; scape 4-12-flowered5. *H. vittata*

1. *Hieronymiella aurea* Ravenna. Sellowia 19: 34-36 (1967). Type: Argentina, Salta, Sierra de Ambato, Spegazzini 1-1897 (holotype, LP!).
Hieronymiella tintinensis Hunz. Kurtziana 4: 7-12 (1967). Type: Argentina, Salta, Dpto. Cachi, Cerro Tintin, 27-II-1965, Hunziker, J. & Naranjo s.n., cult. in Córdoba, in spirit, jar nr. 1188 (holotype, CORD!).



Fig. 2. Prepuna-habitat of *Hieronymiella* in the Province of Salta, Argentina (the habitat of *H. aurea*, not observed in the field by the authors), dominated by the candelabra cactus *Echinopsis atacamensis*.



Fig. 3. *Hieronymiella clidanthoides* in Monte-habitat between Fiambalá and Tinogasta, Catamarca.

Leaves to ca. 1.5 cm broad, margin scabrous. Scape 4-7 (-9)-flowered. Perigone funnelform, (4.5-) 5.5–6.5 (-7) cm long, yellow, perigone-tube 1.3–2.5 cm long. Filaments connate into a 3–5 cm long funnel. Stigma trifid. $2n = 56$ (Di Fulvio 1973: 120; 121, f. 2 A; 123 f. 3, under *H. tintinensis*).

ILLUSTRATIONS. Hunziker 1967: 9, f. 1 (as *H. tintinensis*); Schneckenburger 1992: 111, f. 3; Charpin 1994: 9.

Endemic species of the province of Salta, only known from the departments of Cachi, Molinos and San Carlos, in arid, sandy-stony areas at ca. 2000–3200 m altitude (Fig. 2). Mass flowering of this species was observed by Charpin (1994, see also illustrations in Schneckenburger, 1992). Seeds obtained in 1999 from R. Guaglianone readily germinated, but development of plants is very slow. Plants after several years still produce only narrow filiform leaves.

VERNACULAR NAME. - Amancay, fide Hunziker 1969: 350, en los Valles Calchaquies.

SELECTED SPECIMENS STUDIED. ARGENTINA. **Salta:** *Dpto. Cachi:* Parque Los Cardones, al S de Tintin, 24-II-1999, Guaglianone et al. 3185 (B, SI). *Dpto. Molinos:* entre Seclantás y Molinos, 24-XII-1972, Kiesling 167 (LP). *Dpto. San Carlos:* ladera del Cerro Morado, camino Angastaco-Pucará, 2000 m, Grau 514 (LIL).

2. *Hieronymiella clidanthoides* Pax. Bot. Jahrb. Syst. 11: 327 (1890). Type: Argentina, Catamarca, Dpto. Belén: "Im Becken der Laguna unter dem Thale von Nacimientos", I-1872, Lorentz 449 (holotype, GOET!; iso-type, CORD!). Figs. 3–7.

Leaves up to 4 mm broad, leaf margin smooth. Scape to 30 cm, 2–4 (-7)-flowered. Flowers fragrant, short pedicellate to sessile; perigone funnelform, (9.5-) 10–15 cm long, white, withering with pink flush; perigone tube up to 8.5 cm long; the outer tepals with long apiculate tip (ca. 1 cm long). Filaments connate into a tube or funnel of varying length (0.5–1.6 cm); teeth conspicuous; apical free part of filaments short to absent, anthers sub-sessile on the rim. Stigma trifid. $2n = 56$ (Di Fulvio 1973: 120; 121, f. 2 B; 123 f. 3).

ILLUSTRATIONS. Pax 1890: pl. 7, f. 5–8 (flower); Hunziker 1969: 348, f. 1.

Distributed from the Valles Calchaquies in the SW of the province of Salta to northern Mendoza, generally at a lower altitude than the rest of the species, on sandy ground usually in valley bottoms and near dunes, between 500–2200 m. The showy white and pleasantly scented flowers are presum-

ably nocturnal but remain open during the day. The flowers characteristically age to pink. Floral syndromes suggest sphingid moth pollination.

VERNACULAR NAME. Cebollin, Cebolla de zorro, Sacha cebolla, Cebolla de la vaca (Kurtz in sched., according to Hunziker 1969: 347); “amancay”, in Catamarca, Dpto. Santa María, (according to De Magistris 2004, pers. comm.).

SELECTED SPECIMENS STUDIED. ARGENTINA. **Catamarca:** *Dpto. Andalgalá:* 10-I-1973, Cantino 551 (CORD). *Dpto. Belén:* 29 km N of Belén on Ruta 40 towards Hualfin, 1600 m, 27° 26.03 S / 66° 59.04 W, 20-II-1994, Leuenberger et al. 4255 (B, CORD, ZSS). *Dpto. Pomán,* N del Cajon Mischango, I-1915, Castillon s.n. (LIL 95829). *Dpto. Santa María:* 66 km NE of Hualfin on Ruta 40, 2170 m, 26° 59.34 S / 66° 16.90 W, 22-II-1994, Leuenberger et al. 4316, cult. hort. Berol. 10-VII-2000, Cubr 35859 (B). *Dpto. Tinogasta:* 61 km N of Fiambalá on Ruta Provincial, 2080 m, 27° 12.82 S / 67° 54.77 W, 14-XII-1998, Leuenberger et al. 4689 (B, CORD, ZSS); 79 km on Ruta 11 from Famatina towards Tinogasta, 1470 m, 28° 16.31 S / 67° 38.89 W, 17-II-1994, Leuenberger et al. 4228 (B, CORD, ZSS); 26 km from Copacabana on Ruta 60 towards Cerro Negro, 1150 m, 28° 19.15 S / 67° 19.68 W, 19-II-1994, Leuenberger et al. 4252 (B, CORD, ZSS). **La Rioja:** *Dpto. Famatina:* 68 km N of Chilecito towards Pituil, 1400 m, 28° 35.14 S / 67° 26.83 W, 30-XII-1994, Leuenberger et al. 4393 (B, CORD, ZSS). *Dpto. Independencia:* Guayapa, Establecimiento Santa Rosa 15 km al oeste de Patquia, 17-XI-1963, Hayward & Legname 3188 (LIL). **Mendoza:** *Dpto. Las Heras:* Ramblón, 9-IX-1960, Ruiz Leal 12755 (MERL). **Salta:** *Dpto. Cafayate:* cerca del Mollar, 25-I-1968, A. T. Hunziker & Di Fulvio 19636 (CORD). *Dpto. San Carlos:* San Carlos a Angastaco, 2000 m, 2-I-1979, Grau 95 (LIL). **San Juan:** *Dpto. Caucete:* 16 km of Pie de Palo towards Marayes on Ruta 141, 520 m, 31° 42.67 S / 68° 08.40 W, 12-I-1995, Leuenberger et al. 4464a (B). *Dpto. Jachal:* entre Ischigualasto y Huaco, 18/20-I-1907, Kurtz 14253 (CORD). *Dpto. Sarmiento:* Cañada Honda, 29-XI-1945, Cuezso 1567 (LIL). **Tucumán:** *Dpto. Tañi del Valle:* Amaichá, camino a Santa María, II-1914, Castillon 3426 (LIL).

3. *Hieronymiella marginata* (Pax) Hunz. Kurtziana 5: 355 (1969).

Eustephia marginata Pax. Bot. Jahrb. Syst, 11: 328 (1890). Type: Argentina, La Rioja, Sierra Famatina, La Encrucijada, 2500–3000 m, 29-I- & 2-II-1879, Hieronymus & Niederlein 496 (lectotype, B!; isotypes, B!, CORD!, G!, K!). Figs. 8–12.



Fig. 4. *Hieronymiella clidanthoides* with open (white) and spent (pink) flowers (same locality).



Fig. 5. *Hieronymiella clidanthoides* from Catamarca flowering in cultivation (Leuenberger et al. 4689).

Hieronymiella argentina (Pax) Hunz. & S.C.Arroyo. Kurtziana 24: 154 (1995). *Eustephia argentina* Pax. Bot. Jahrb. Syst. 11: 324 (1890). Type: Argentina, Catamarca, Cuesta de la Negrilla y del Durazno, XI-1872 & XII-1873, Schickendantz 58 (holotype, B!). **Synon. nov.**

Hieronymiella latifolia (R. E. Fries) Di Fulvio & Hunz. Kurtziana 8: 81 (1975). *Hieronymiella marginata* var. *latifolia* (R. E. Fries) Hunz. Kurtziana 5: 357 (1969). *Eustephiopsis latifolia* R. E. Fries. Nov. Act. Reg. Soc. Upsal. ser. 4, 1(1): 164 (1905). Type: Argentina, Jujuy, Saladillo, 3500–4000 m, 12-XI-1901, G. V. Hofsten in Fries 753 (lectotype, here designated, S!; isotypes, CORD!, UPS).

Hieronymiella tarijensis (Fern. Casas & R. Lara) Fern. Casas & R. Lara. Fontqueria 44: 244 (1996). *Androstephanos tarijensis* Fern. Casas & R. Lara. Fontqueria 4: 33–36 (1983), repeated in Herbertia 41: 74–75 (1985). Type: Bolivia, Tarija, O'Connor, Río Narváez, 1470 m, 18-VIII-1981, R. Lara 1842 (holotype, MA, photo at B!; isotype, cited for G but not located).

Hieronymiella ferruginea Ravenna. Onira 4(7): 25–26 (2000). Type: “Floruit in Santiago ex ditioe El Duraznito ad meridionem viae Salta-San Antonio de los Cobres prov. Salta”, XII-1982, Ravenna 2601 (holotype, herbarium Ravenna, not seen). **Synon. nov.**



Fig. 6. *Hieronymiella clidanthoides*, near headquarters of Parque Nacional de Talampaya, La Rioja, Argentina. Plant with fresh white, older pink, and spent flowers.

Hieronymiella angacoana Ravenna. Onira 4(7): 26–27 (2000). Type: Argentina, San Juan, Dpto. Angaco, camino al Mogote de los Corralitos, 23-XII-1984, Kiesling 4796 (holotype, SI!) (Note: not Kiesling “4786” as published in the protologue, a number not pertaining to an Amaryllidaceae).

Synon. nov.

Leaves up to 2 cm broad, leaf margin finely cartilaginous-scabrous. Scape (3–) 4–10 (–18)-flowered. Perigone tubular, 2.5–3.5 cm long, red to orange-red or pale rose, red and greenish in various combinations; tube short, 2–4.5 (–7) mm long. Filament wings shortly connate (1–1.5 cm); teeth rounded to acute, the apical free part of the filaments longer than the teeth. Stigma capitate to 3-lobed. $2n = 54$ (Di Fulvio 1973: 122; 121, f. 2 C; 123 f. 3). $2n = 60$ (Di Fulvio 1973: 120; 119, f. 1 B, under *H. marginata* var. *latifolia*).

ILLUSTRATIONS. Hunziker 1969: 354, f. 3; 358, f. 4 (as *H. marginata* var. *latifolia*).

This species has the broadest geographical and altitudinal range of all hieronymiellas. It occurs from southern Bolivia to the province of San Juan in western Argentina, between 1470 and 4000 m.

VERNACULAR NAME. Cebolla de zorro (Kurtz in sched., fide Hunziker 1969: 355); “charagua” (en sched.).



Fig. 7. *Hieronymiella clidanthoides*, near headquarters of Parque Nacional de Talampaya, La Rioja, Argentina. Close-up of flower.



Fig. 8. *Hieronymiella marginata* in Puna-habitat in Jujuy.



Fig. 9. *Hieronymiella marginata* cluster of flowering bulbs (same locality, Leuenberger et al. 4585).

TAXONOMIC NOTES ON SYNONYMS. *Hieronymiella argentina*. This species was described together with *H. marginata*; both names are based each on a single specimen. The minimal differences indicated in the descriptions are impossible to verify in the type material and could neither be substantiated in further herbarium studies. Arroyo-Leuenberger and Leuenberger (1996) erroneously mentioned *Eustephia marginata* as a synonym of *Hieronymiella argentina*. The combination *H. marginata* was made by Hunziker (1969), and this name has priority if the two names belong to the same species.

Hieronymiella latifolia. The detailed illustrations by Hunziker (1969) of *Hieronymiella marginata* var. *latifolia* from Jujuy as compared with *H. marginata* from Catamarca show slight differences in filament characters. These characters are not explicit in the protologues of the two taxa, not supported by the type material, and fall entirely into the variation observed within single populations. The elevation of *H. latifolia* to species level by Hunziker (1975) was based on cytological studies. It was supported by Ravenna (2000). The cytological differences remain an interesting case for additional studies. However, such differences are not exceptional within one species, as the example of *Rhodophiala bifida* with ($x = 8$ and $x = 9$) shows (Naranjo and Poggio, 2000). Arroyo-Leuenberger and Hunziker (1995) placed *H. latifolia* in synonymy with *H. argentina*, without mentioning *H. marginata*. In 1998, ample material from the area of the type locality of *H. latifolia* (Jujuy, Saladillo) was collected by the authors and well documented also by photographs in the field (Leuenberger et al. 4585, see Figs. 9 and 12 in this paper). The comparison with the type specimens of both *Eustephia marginata* and *E. argentina* as well as with the type of *Eustephiopsis latifolia* provides strong evidence that all three belong to the same species, which must consequently bear the name *Hieronymiella marginata*.

Considerable variation in flower color was observed within one population and also within the species (Table 1). Regional differences are possible. Differences are reflected by color data compiled from herbarium labels. Indications of colors must be taken with some precaution, as they normally do not follow standard charts and convey personal impressions influenced by daylight conditions.

Hieronymiella ferruginea. The description of *Hieronymiella ferruginea* is based on a single specimen kept in the private herbarium of P. Ravenna. It is said to be similar to *H. marginata* from which it purportedly differs by a lower habit, reddish scape, brownish green leaves and a rosy tone of the



Fig. 10. *Hieronymiella marginata*, specimen prior to preparation for the herbarium, showing bulb, leaves, and inflorescence (Leuenberger et al. 4529).

flowers. Observation of our own collection (Leuenberger et al. 4610, now identified as *H. marginata*) from the general area of the type collection of *H. ferruginea* shows considerable variation of scape length and flower color (from red to rosy and yellowish-orange-yellow with reddish venation) which would seem to include the plant described by Ravenna as *H. ferruginea*. It should also be noted that, in the description of *Eustephia marginata*, Pax (1890) mentions a peduncle length of 12 cm, which is actually lower than the 13 cm indicated by Ravenna for *H. ferruginea*.

Hieronymiella angacoana.

According to the protologue, the morphology and color of

the flower of *H. angacoana* are very similar to that described for *H. argentina*. A revision of the type specimen of *H. argentina* at Berlin-Dahlem (B) reveals that the length of the tepals varies from 2.5–3 cm and the length of the tube does not normally surpass 5 mm. This contradicts the differences mentioned by Ravenna, who describes *H. angacoana* as “perigone 25–32 mm with tube 5 mm”, and *H. argentina* as “perigone 40 mm with tube 10 mm.” There can be hardly any doubt that *H. angacoana* falls within the range of variation of *H. marginata*. The report is nevertheless of interest as it constitutes the southernmost record of a member of section *Synexa*.

SELECTED SPECIMENS STUDIED. ARGENTINA. **Catamarca:** *Dpto. Andalgalá:* 1700 m, 29-XI-1948, Filipovich 177 (LIL). *Dpto. Belén:* hill at culmination of first pass on Ruta 53, 54 km from turnoff from Ruta 40, 3350–3400 m, 26° 51.94 S / 66° 45.11 W, 20-II-1994, Leuenberger et al. 4262a, cult. hort. Berol., 12-VI-2001, Cubr 38707 (B). **Jujuy:** *Dpto. Santa Bárbara:* Ruta 1, camino de Humahuaca a Tilcara, 11-XI-1996, Daviña et al.

356 (B, MNES). *Dpto. Tilcara*: Tilcara toma de agua, 12-XI-1985, Krapovickas & Cristobal 40282 (B, C, CTES). *Dpto. Tumbaya*: on Ruta 52, at turn-off of Ruta 78/79 towards El Moreno, 3850 m, 23° 42.59 S / 65° 41.57 W, 30-XI-1998, Leuenberger et al. 4585 (B, JUA, ZSS), Quebrada de Humahuaca, 11 km N of Tumbaya towards Purmamarca-Tilcara, 2100 m, 23° 46.25 S / 65° 28.75 W, 25-XI-1998, Leuenberger et al. 4529 (B, JUA, ZSS). **La Rioja**: *Dpto. Famatina*: 4-II-1956, Calderon 1057 (BAA). **Salta**: *Dpto. Cachi*: Parque Los Cardones, al S de Tintin, 24-II-1999, Guaglianone et al. 3184 (B, SI). *Dpto. Iruya*: Iruya, 2750 m, 15-X-1949, Vervoorst 503 (LIL). *Dpto. Rosario de Lerma*: 58 km SE of San Antonio de los Cobres towards Salta, 3230 m, 24° 25.79 S / 65° 58.79 W, 2-XII-1998, Leuenberger et al. 4610 (B). **San Juan**: *Dpto. Angaco*: Sierra Pié de Palo, 23-XII-1984, Kiesling et al. 3107 (SI). **Tucumán**: *Dpto. Tañi del Valle*: Cumbre de Anfama, 2600 m, 24-XI-1927, Venturi 5693 (LIL). *Dpto. Trancas*: Cumbres Alta del Chorro, 4000 m, IX-1918, Schreiter 843 (LIL).

A closely allied taxon, probably another synonym of *H. marginata* is listed here as under observation:

Hieronymiella pamiana (Stapf) Hunz. Kurtziana 8: 80 (1975). *Eustephia pamiana* Stapf. Bot. Mag. 153: tab. 9164 (1927). Type: Argentina, Tucumán, cult. comm. from Major A. Pam, Wormley Bury, Broxbourne, April 1926 (holotype, K!).

This species was described from cultivated material "Raised by Major Pam in 1926 from bulb received from Tucumán flowered in his garden Wormley Bury, Broxbourne, April". Stapf mentioned it as similar to *Eustephia argentina*, from which he separated it by the greenish apex of



Fig. 11. *Hieronymiella marginata*, inflorescence with flower buds, flowers (one opened) and young capsule (Leuenberger et al. 4529)

the perigone and the slightly glaucous leaves. Our collection from Belén, Catamarca (Leuenberger et al. 4262a, cult. in hort. Berol., Cubr 38707, B), agrees remarkably well with the description and illustration published by Stapf (1927) and the original deposited at K together with the type specimen. Hunziker (1975), when making the combination *Hieronymiella pami-ana*, noted the similarity with *H. marginata*. The same chromosome number $2n = 54$ was found by Di Fulvio (1975: 144, f. 1). More data are necessary to decide if this represents a clearly distinguishable entity.

4. *Hieronymiella speciosa* (R. E. Fries) Hunz. Kurtziana 5: 351 (1969).

Eustephiopsis speciosa R. E. Fries. Nov. Act. Reg. Soc. Sc. Upsal. ser. 4, 1 (1): 163 (1905). Type: Argentina, Jujuy, Dpto. Cochinoca, Tres Morros ad Salinas Grandes, 3300 m, 27-XII-1901, Fries 948 (lectotype, here designated, S!); Miraflores, 12-II-1901, Claren in Herb. Kurtz 11643 (syntypes, S!, CORD!); Laguna Tres Cruces, ca. 3700 m, 31-XII-1901, F. Claren in Herb. Kurtz 11319 (syntype, CORD!); Dpto. Humahuaca: Uquía, 2800 m, 20-II-1901, F. Claren in Herb. Kurtz 11723 (syntypes, S!, CORD!).—Figs. 13–15.

Leaves up 4 mm broad. Scape 1–3 (-4)-flowered. Perianth funnel-form to crateriform, 3.2–5.2 cm long, white with faint pink red venation, perigone tube short, 2–5 mm long; the outer tepals with long apiculate tip (ca. 1 cm long). Filaments green, only shortly connate (0.3–0.6 cm). Stigma trifid.



Fig. 12. *Hieronymiella marginata*, flowers and longitudinally sectioned flowers, variation of flower color (Leuenberger et al. 4585).



Fig. 13. *Hieronymiella speciosa* flowering specimen in cultivation, originally from Salta (Leuenberger et al. 4593a).

$2n = 42$ (Di Fulvio 1973: 120; 121; 119, f. 1 A.).

ILLUSTRATIONS. Fries 1905: pl. 8, f. 14, 15 (as *Eustephiopsis speciosa*); Hunziker 1969: 352, f. 2.

This species had been cited before only for Jujuy, but occurs also near San Antonio de los Cobres, Salta. It grows in sandy rocky soil, between 2600 and 3900 m altitude.

VERNACULAR NAME.

Payotica (flor de las nubes), Puyapuya (Claren in sched., according to Hunziker 1969: 351).

SELECTED SPECIMENS

STUDIED. ARGENTINA. Jujuy:

Dpto. Cochinoca: Casabindo, 18-X-1948, Cabrera 9325 (BAB).

Dpto. Humahuaca: Humahuaca, 2950 m, 28-II-1953, Hjerting &

Petersen 960 (C). Dpto. Tumbaya: Abra de Pibes, 3500–3900 m, 5-I-1953, Sleumer 3286 (LIL.). Dpto. Yavi: La Quiaca al W del pueblo, 5-II-1948, Vervoorst (LIL. 238259). Salta: Dpto. San Antonio de los Cobres: 8 km W of San Antonio de los Cobres on Ruta 51 towards Paso Sico, 3850 m, 24° 15.08 S / 66° 22.52 W, 30-XI-1998, Leuenberger et al. 4593a, cult. hort. Berol., 4-VII-2003, Cubr 40815 (B).

5. *Hieronymiella vittata* Ravenna. Onira 5(10): 50 (2001). Type: Argentina, Salta, Quebrada de Incahuasi, aguas abajo de Angostura de Pascha, 3300 m, 18-II-1932, Kerdel (holotype, LP!).

Bulbs and leaves unknown. Scape 4–12-flowered. Perianth funnellform, 3.5–4.5 cm long, white with red striation (according to the collector), perigone tube short, 5–6 mm long. Filaments shortly connate. Stigma trifid.

Ravenna based this species on two old herbarium specimens. He placed it in the key next to *H. speciosa* but noted that inflorescence and flower structure is reminiscent of *H. clidanthoides*, which is why he submerged sect. *Eustephiopsis* in sect. *Hieronymiella* in the same paper. The type specimen

has numerous flowers but the interior characters are not visible. Adequate material and field observations of this insufficiently documented taxon are necessary.

SELECTED SPECIMENS STUDIED. ARGENTINA. **Salta:** [Dpto. Rosario de Lerma]: Quebrada Barreal, lado izquierdo de la Quebrada del Toro, 3300 m, 15-II-1932, Kerdel (LP).

DOUBTFUL NAMES

Hieronymiella angustissima Ravenna. Onira 5(13): 62–63 (2001). Type: Argentina, Jujuy, Dpto. Humahuaca, Humahuaca 20-II-1927, Fiora (holotype, BA!).

According to the protologue, the type specimen is the only material known. It is an old collection lacking flowers, which are essential to prove that this is really a new species of *Hieronymiella*. Therefore, it seems preferable to treat this name as dubious until new records are available.

CONSERVATION STATUS

No concise data on the conservation status of *Hieronymiella* species are available. From herbarium documentation and from our own field observations, it is not easy to accurately apply the assessment criteria that allows placement of each species in one of the categories proposed by IUCN



Fig. 14. *Hieronymiella speciosa* flower, frontal view (same specimen).



Fig. 15. *Hieronymiella speciosa* flower, longitudinally opened (same specimen).

(2001). The habitats of members of this genus do not seem under particular pressure, as they are mostly in areas of minimal land use. Only a few are easily accessible by road. Local threats are nevertheless possible. No particular threat by collecting is known.

*Hieronymiella*s have not been widely exploited by horticulture and are unlikely to become so. The most widespread species, *Hieronymiella clidanthoides* and *H.*

marginata, are by no means frequently encountered.

However, as can be expected in bulbous plants with a short season of growth above ground, and that are conspicuous only when flowering, little

is known about true population size. The two species are not as widespread and numerous as to clearly be of "LC = least concern." They could be classified as "NT = near threatened" in their natural habitat, due to overgrazing or from selective collecting for whatever reason, but there is little evidence to confirm the severity of such threats. The other more rare and insufficiently known species cannot be assessed properly until more data are available. *H. aurea* has a very limited range and could easily become endangered, but is fortunately located mainly within a national park. *H. speciosa* is probably more widespread than indicated by the few known collections, but might be classified as "NT = near threatened" from the data available.

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All photographs by B. E. Leuenberger (scales are in centimeters)

Table 1. Flower colors of *Hieronimiella marginata* indicated on herbarium labels.

PROVINCE	DEPARTMENT	COLOR
Catamarca	Belén	red with greenish apex
Jujuy	Tilcara	red
Jujuy	Tumbaya	yellow-orange with red striations, pinkish-brick-red to fire-red tip with orange center
La Rioja	Famatina	red
Salta	Rosario de Lerma	orange with red striation
Salta	Cachi	orange, rosy red
Tucumán	Tafi del Valle	rosy, red (4x)
Tucumán	Trancas	brick-red, rosy

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PERSPECTIVES IN THE DOMESTICATION OF NATIVE ISRAELI GEOPHYTES

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INTRODUCTION AND SHORT HISTORICAL REVIEW

The eastern Mediterranean and especially the coasts of the Levant are the native home of a colorful assemblage of wild bulbous plants, many of them highly ornamental. About 500 species comprise the core element of this wealth. Although some of these have been domesticated over the past 400 years, the major part of this richness has not been translated to commercial commodities.

Israel, by its geographic location, climatic conditions and socio-economic status is a major floricultural producer. It could become a natural center for the domestication and commercialization of the local geophytic flora. Since 1920 sporadic efforts were made here in this direction, but only in the course of the past 20 years has a more systematic push to develop this "gold trove" been undertaken. Industrial and agricultural developments as well as urban sprawl threaten this unique resource, in spite of a well-developed local nature conservation system. Thus, a review of this theme is urgent. The present paper aims at reviewing the past, summing up present work and outlining future promising directions of development.

THE LOCAL ENVIRONMENT

The climate of the eastern part of the Mediterranean basin is distinctly more continental and more arid than in the western Mediterranean (Blodel and Aronson, 1999). It is more unpredictable and the seasons less equable. The summer is hotter with lower humidity; the winter is colder with intermittent warm periods. The rains start later and are less abundant. The eastern Mediterranean is also nearer to the large semi-arid centers of southwestern and central Asian biodiversity. Herbaceous plants (annuals, herbaceous perennials and especially geophytes) are well adapted to these conditions,

comprising more than half of the native flora. Among the drought evading species (roughly 2/3 of the total flora), geophytes account for 232 species or 7.88 % (Fragman et al. 1999), and are thus a prominent element (Table 1).

The unique evolution of the vegetation during recent geological history and the very significant secondary speciation (e.g. the *Oncocylus* irises) have resulted in a geophytic flora that is adapted to this seasonal climate. It is unique for the richness of showy species that are limited to this part of the world. Many of these geophytes are rare and endemic to very small geographical areas.

THE HISTORY OF BULB GROWING IN ISRAEL

From 1921 through 1945 there was no real commercial bulb growing in the area that now comprises Israel (Weijel, 1966, 1996). When Zohary and Feinbrun (1930) reviewed the useful plants of Israel, the only geophytes mentioned were *Narcissus* and *Hyacinthus*, but only as raw materials of the perfume industry. During this period, bulbs were mainly cultivated in very limited quantities for gardening. Later, Halevy, the founding father of floriculture in Israel, reviewed the potential of this group (Halevy, 1962, 1989). Horowitz and Danin (1983) reviewed the wild relatives of ornamental plants; they analyzed the case histories of *Anemone coronaria*, *Cyclamen persicum*, *Hyacinthus orientalis* and *Lilium candidum*. They concluded that none of the cultivated material of these were derived from the native Israeli gene pool of the species. However, they refrained from an assessment of the potential new ornamentals among the many other native species, observing only that “numerous garden-worthy species of Israel, some of them close relatives of the ones actually introduced to cultivation, were by-passed and still await cultivation.” This is still true to this day.

During the period 1945–1955, small-scale commercial bulb cultivation developed, particularly that of *Gladiolus* corms. The experience gained during this period resulted in the awareness that the climatic conditions in Israel might have some distinct natural advantages for growing geophytes. In 1954, the late Zvi Gazit successfully exported the first commercial consignment of flower-bulbs to the United States from Kibbutz Gevim.

From 1955 until 1965, a tremendous effort was made to develop *Gladiolus* and “Dutch” *Iris* production for export. This effort was not successful, however, primarily because the material that originated in Holland suffered from latent phytopathological problems. (Vigodsky-Haas et al., 1988). Lack of promotion and marketing and the resulting low profits also hampered the crop at



Fig. 1. *Allium nigrum*.

this stage. The effort Zvi Gazit made to develop some wild species as commercial crops was discontinued after his untimely death. It was therefore decided in the years 1963–1965 to assign very low priority to bulb growing and to shift the main development effort to cut flowers like roses.

Notwithstanding this decision, during the period 1965–1996, a very select group of growers, extension officers and research workers carried on, and succeeded in developing production methods and an export market, especially for paper white *Narcissus*, *Ranunculus*, *Liatris*, *Anemone* and *Hippeastrum* bulbs. In addition,

production of *Lilium longiflorum*, *Aconitum* and *Eremurus* was developed to supply Israeli flower growers with planting material.

The results of these efforts are reflected in the 1994–1995 export figures (Table 2). These reached a value of \$20.1 million for bulbs and for flowers grown in Israel from locally produced bulbs. This figure represents approximately 10% of the value of all Israeli ornamental plant and cut flower exports. Production of bulbous plants in Israel serves cut flower production, garden and landscape planting and the production of flowering pots. Today, the export value of geophyte products is 10 million US\$ for propagation material and 40 million US\$ for cut flowers of geophytic plants.

Working on this history, it became clear to us that, while very professional growers now carry out bulb growing, the key factor to success is the collaboration that occurs all along the production and marketing chain. Furthermore, and no less important, several very capable and highly motivated extension and research workers are “supplying” the Israeli bulb growing industry with an increasing stream of knowledge and breeding products. Several of the producers are themselves active in breeding programs.

All this may again increase the potential value of the indigenous Israeli flora's gene pool.

In conclusion, it can be said that the flower-bulb industry is based on professional know-how of a selected group of growers, extension, research and marketing specialists. With those resources, it does not seem too optimistic to expect that, by the end of this decade, considerable development in Israeli flower bulb growing will be realized.

THE PRESENT: PRODUCTS, PRODUCTION CENTERS AND EXISTING AGRICULTURAL TECHNOLOGY

CASE HISTORIES

On the basis of economic significance, present production procedures and potential value, Tables 3–7 summarize the salient features of all relevant species. The most promising species, already on the market or in the process of introduction, are described in detail.

ALLIUM

From about 700 described *Allium* species, about 20 have successfully been adopted as ornamental and cut flowers (e.g. *A. giganteum*, *A. aflatumense* and *A. sphaerocephalum*—all native to cool temperate regions). This is also the largest local bulbous genus with 35 species ranging throughout Israel



Fig. 2. Wild *Cyclamen persicum* cultivated in Mt. Carmel.

from sub-alpine Mt Hermon, throughout Mediterranean areas, to the deserts. The dominant inclination of the market is towards large-headed tall species developed as cut flowers. In line with this trend a number of showy species can be distinguished in the local flora.

Allium ampeloprasum is a common element of disturbed Mediterranean areas. The globular, dense umbel is up to 10 cm in diameter on a scape up to 2 m tall. The flowers are whitish green to dark purple, blooming from June until July (–August). Early blooming in March–April was achieved in forcing trials (Lahav, 1990). Under cultivation, the plants suffer from viral infections and rusts. These problems are avoided by seed propagation. First blooming is achieved after 3–4 years; however, the mother bulb does not persist and disintegrates into 100–250 tiny bulblets. Bulblet growth is erratic and flowering requires as long a production period as seed (Watad, 1995).

Allium aschersonianum is sparsely distributed in the Transition Zone between the Mediterranean and the desert regions. It appears locally in large stands in the Jordan Valley. The dark violet-purple heads, densely set with starry flowers, are up to 15 cm in diameter, on scapes 60–100 cm tall. The flowering display is a stark contrast to the species' austere habitat. In the wild, flowering occurs in March–early April; under cultivation blooming begins as early as February, and can be extended by staggered planting (Kamenitzki, pers com.). The main obstacle to commercial development of this species is the short bulb viability and its low vegetative propagation rate. Trials to increase vegetative propagation failed to produce significant results (Kamenitzki, pers com.). Seed propagation is thus preferred, but bulbs do not flower before they are three years old.

Allium nigrum (Fig. 1) is sparsely distributed in northern Israel, usually in deep alluvial soils, but occasionally in rocky habitats on terra-rosa or basalt. The flowering head is 5–10 cm in diameter on scapes 60–100 cm tall. Local populations are distinguished by dark, shiny ovaries and variable perianth segments, ranging from greenish white, white, light lilac to purple, which strongly contrast with the dark ovary. Blooming time in the wild is March–April. In cultivation, flowering can be forced in February using cooling (to 9° C) and growing on in an unheated greenhouse. As with *A. aschersonianum*, commercial development is hampered by the short life cycle of the mother bulb, thus seed propagation is required.

In addition, *A. neapolitanum*, *A. orientale*, *A. phaneranthrum*, *A. schubertii* and *A. tel-avivense* are cultivated on a smaller scale. These and other species are currently under assessment and development. This is a large

promising group that still requires much physiological, morphological and phytopathological work in order to develop routine cultivation manuals for each species, as well as the development of commercial propagation to maintain a routine supply of cultivated material.

ANEMONE

Anemone is one of the top ten outstanding mid-winter export cut flowers. It was first introduced to local cultivation in the sixties, as the De Caen variety group, which dominated in cultivation until 1978. The corms were annually imported (Ozeri, 1983) and forced according to a protocols described by Luria (1989) and later improved by Umiel and Hagileadi (1996). However, when forced, imported corms flowered relatively late, apparently due to a high chilling requirement. The need for an early flowering form with a low chilling requirement was met by Horowitz (Horowitz et al., 1975) who crossed De Caen varieties with the local races. The results, known as "Jerusalem Varieties," satisfied the need for a low chilling requirement in early forcing and provided good cut flowers for the winter export season. Crossing De Caen with Jerusalem varieties gave rise to additional varieties ('Galilee' and 'Meiron') that were developed in the Galilee. This improved the flowering quality of the species under cultivation.

In spite of this success, further development was hampered by a number of phytopathological and physiological problems (Enav et al. 1995). Solar soil sterilization provided a partial solution. But this did not solve the problem of *Colletotrichum acutatum*, accidentally introduced with European germplasm. The fungus is controlled by application of Prochloraze (Friedman et al., 1999).

Anemone is an excellent example of the successful domestication of native wild flower germplasm in subtropical regions, and can serve as an example for other native wild flowers from the Eastern Mediterranean basin. Future breeding directions could follow the pattern of the Mona Lisa group of varieties by introducing double and semi-double flowered forms (e. g., 'St. Brigid') for early flowering.

CYCLAMEN PERSICUM

The genus *Cyclamen* is represented in the native flora by two species: *C. persicum* (Fig. 2) and *C. coum*. *C. persicum* occurs in isolated populations in Greece and Turkey but forms continuous populations in western Syria, Lebanon, northern and central Israel and western Jordan. It is a common element of rocky slopes (0–1300 m), but is occasionally found in the coastal sands of Israel and other habitats. The species is self-pollinating. Seeds are

dispersed passively to adjacent soil pockets and also by ants. Within ant nests, seeds germinate under stable temperature conditions of 17° C and darkness (G. Luria, pers. obs.). The typical flowering season is January–March (–April); however, hysternanthous to sub-hysternanthous forms have been observed from late October and November in the steppes of eastern Samaria and southern exposures in the Galilee and on Mt. Carmel. These were described as *C. persicum* var. *autumnalis* (Grey-Wilson, 1997).

Wild populations are considerably variable in flower color and size, as well as leaf patterning. Double and fragrant forms are occasionally encountered. The origin of the many cultivated varieties is not clear; however, *C. persicum* is considered the parent form of all the cultivars developed in The Netherlands. These are mostly tri-, tetra- or even octoploids. The high ploidy forms are less viable and more disease prone, thus a return to wild type germplasm for breeding and selection of novel forms is important.

At present, cultivated forms exported from Israel (about three hectares in production) perform best in Mediterranean-type environments and suffer from frost damage in cool temperate gardens. This limitation could be avoided by the introduction of *C. coum*, native to colder habitats, ranging from 1000 to 1900 m elevation. This plant is smaller in corm, leaf, flower size and flower number. The petals are rounded, dark violet pink, with a dark purple dot at the petal base. Although some wild collected material from Turkish provenance is on the market, there is scope for greater production of this species and exploitation of its range of variation.



Fig. 3. *Iris vartanii*

IRIS

Some 15 *Iris* species are native to Israel, with more than half very rare, narrow endemics that are protected by law. Extremely showy, they consti-

tute one of the least developed native floristic elements for ornamental horticulture. Though commercial exploitation was started in the sixties and seventies and continues to date (see Tables 1 and 6), its scale is limited and not representative of the potential value of the genus in the range of commercial products that it can provide. Israeli *Iris* species can be roughly divided among the four subgeneric groups: subgenus *Xyphium* (*I. histrio* and *I. vartanii*, Fig. 3); corms for garden and container cultivation; subgenus *Iris* sect. *Oncocyclus* (*I. atropurpurea*, *I. hayneii*, *I. hermona*, *I. lortetii* and *I. mariae*), cut-flowers and rhizomes for gardens; subgenus *Scorpiris* (*I. grant-duffii*), rhizomes for garden use; and subgenus *Juno* (*I. palaestina* and *I. regis-uzziae*), bulbs for garden and container cultivation.

Since their first description, in the middle of the eighteenth century (Dykes, 1913), the members of the section *Oncocyclus* have been considered of great beauty and sometimes over-collected to extinction. (Cohen and Avishai, 2001). All the species of section *Oncocyclus* are self incompatible and often very variable. Y. Sapir and colleagues (2001) analyzed morphological diversity among populations of the species and concluded that three dark-colored species from the Haynei aggregate constitute a single phylogenetic species (Avishai & Zohary, 1977).

Avishai and Zohary (1977) found that all *Oncocyclus* species have the same chromosome number and a very similar karyotype. They also found that the group lacks the development of post-zygotic reproductive isolation barriers and are freely crossable, thereby constituting a single germplasm pool (Avishai and Zohary, 1980). Abraham Halevy and his collaborators at the Volcani Center have studied the shelf life of the cut flowers.

Cultivation of members of the section *Oncocyclus* and hybrids derived from within it or from crosses with other species from subgenus *Iris* has been tried several times in Israel and abroad. The first attempt on a commercial scale in Israel was by Tzevi Gazit-Ginzburg at Kibbutz Gevim in the early nineteen sixties. David Shahak at Kibbutz Tirath Tzevi began the second trial a few years later. Both used true species and polyploid or amphidiploid hybrids developed locally or abroad. *Iris lortetii* was tried twice: at Sdeh Eliezer by Yitzhak Kaminer and at Moledet by Amnon Blumenthal. All of these trials failed commercially. Only true *Iris atropurpurea*, cultivated on a relatively modest scale for cut flowers within the original species geographic range by Gideon Lahan at Rishpon, has survived on the market.

The reasons for the commercial failure were the narrow ecological tolerances of the plants and their notoriously difficult seed propagation. The lack



Fig. 4. *Ixiolirion tataricum*

of hardiness and the need of the rhizomes for very dry, hot summers are liabilities as well. High susceptibility to viral infection and fungal leaf diseases during the growing season also caused a great deal of loss. In addition, even the slightest damage during rhizome harvest facilitates additional bacterial diseases. A significant breakthrough in the cultivation of this group requires development of strains with virus-resistance and a guaranteed shelf life quality, as well as a suitable forcing protocol.

IXIOLIRION

Israel is located on the southwestern border of the extensive geographic range area of this small Central and Southwestern Asian genus of ornamental, blue flowering bulbs (Fig. 4). Protected by law, it is occasionally encountered in the cool and arid Irano-Turanian steppes of the Central Negev Highlands and those surrounding the Rift Valley and Mount Hermon. It is one of the minor bulbs traded on the world market for garden and container cultivation (Bailey, 1939; Griffiths, 1994; Bryan and Griffiths, 1995).

Experimental cultivation in Israel started in the sixties but was discontinued. In 1993, work was renewed, but bulbs cultivated in Holland and imported to Israel failed to grow and flower (Ephron et al., 1996). Therefore, several native populations from three sites in the southern part of Israel were tested for natural morphological diversity and seed yield as part of the assessment of their potential for domestication.

Bulbs from the wild do not produce more than eight flowers per scape, with stem heights up to 50 cm. Their color varies from light blue to dark violet. Under cultivation, 100% seed germination was achieved at 9° C after 23 days (Ephron et al, 1996). The kinetics of seedling and bulb growth were

also studied (Galil, 1961). Low temperatures induced renewed bulb growth and sprouting. Selected large bulbs produced up to 23 flowers in 2 or 3 dense umbels. Low temperature (9° C) induction for flowering was also tested, and resulted in a January flowering as opposed to the normal flowering in March–May. Cut flowers lasted up to seven days (Ephron et al., 1996).

Present results indicate that much more biological and agro-technical work is needed to develop this species as an economically useful crop. A number of areas of Israel can meet both its summer (hot and dry) and winter (some degree of chilling) requirements, which indicates the promise of *Ixiolirion* as a future cut-flower.

LILIUM CANDIDUM

This is a perennial herbaceous geophyte with beautiful, fragrant large flowers. It is mentioned in the Bible as an emblem of chastity and beauty. In the Catholic tradition it is known as the Madonna lily or Easter Lily, symbolizing the purity of the Virgin Mary. The Crusaders collected the bulbs almost to extinction, and that is the reason for its rare occurrence in nature. During the second quarter of the 20th century the species was rediscovered by Otto Warburg near Methula, by Noah Naftolsky near Peqein and later by Tuvia Kushnir on Mount Carmel. In the late sixties it was also discovered in the Western Galilee. It occurs on moist cliffs and rocky slopes on north facing exposures in maquis vegetation. Wild populations are distinguished by considerable variability in annual flowering dates, number of flowers, size of foliage and bulb quality. Often such wild forms do not suit domestication. Mrs. S. Keshet, from Moshav Lachish, selected from an unknown source a variety currently cultivated in Israel under the name 'Shosha'.

The cultivated forms of *L. candidum*, exported today from Greece, Turkey, and Syria, were probably originally wild-collected and are similar to the local wild form in Israel. In nature, the plants flower during the first and second week of May, irrespective of the preceding winter's amount of rainfall. Experiments to induce flowering under different day length regimes have failed (Rivlin, 1984). The commercial promotion of this plant as a cut flower is based on a misnomer, as the plant sold currently as the "Easter Lily" (*Lilium longiflorum*) is actually a member of a different group of species, and is much easier to force. Currently, efforts are under way to develop a novel superior hybrid form of the two species.

NARCISSUS

This genus is represented by two wild species, the autumnal small-flowered *N. serotinus* and the winter flowering *N. tazetta*. H. Yahel (A. Cohen, pers. com.) collected different ecotypes of *N. tazetta*. Following this work, a cytological systematic study was published (Weitz and Feinbrun, 1972). In both studies, material from the two significant habitat types (winter-inundated heavy valley soils and rocky mountain slopes) was investigated. When cultivated under equal conditions, flowering dates of plants originating from both habitats differed by only a week in contrast to a larger difference in nature (8–12 weeks, Rotem Database). A series of attempts to hybridize *N. tazetta* and *N. papyraceus* were conducted in order to combine the positive traits of both species (flower number in *N. papyraceus*; stalk strength, fusarium and virus resistance and flower scent in *N. tazetta*). All but one of these attempts had low progeny viability and were considered failures. In the single successful case, the chromosome number was found to be $x = 11$ in both parents). Intermediate color forms and scent variants were observed.

Today, material originating from the wild is not cultivated on a commercial scale. The locally cultivated taxa from the *tazetta* group are 'Grand Soleil d'Or', a western Mediterranean garden origin scented form of *N. tazetta* with golden perianth and orange cup; *N. papyraceus*, a west Mediterranean pure white-flowered species; and ancient local double forms of *N. tazetta*. Other varieties appear on occasion in gardens. Future development of this crop should entail the combination of white color for the Christmas season with the fragrance of the wild form.

PAEONIA

Paeonia mascula, a herbaceous peony, is the single species of the genus native to one site in northern Israel. Experimental work conducted on hybrid varieties developed abroad started in 1986 (Halevy, 1990). This work may well contribute towards the cultivation of *P. mascula*. In order to test this assumption, a cultivated population of this species must be established and tested. However, its domestication is severely constrained by a low vegetative propagation rate and poor seed germination, as well as slow maturation (four to five years from seed to first flower). The single flower has good color, but the features of the wild form are not of sufficient quality for either garden usage or cut flower production. Hybridization and breeding with other species or varieties would certainly increase the commercial value of this species in the future.



Fig. 5. *Scilla hyacinthoides*.

SCILLA

This large genus has been split into a number of genera (Mabberley, 1997). The most outstanding local species is *Scilla hyacinthoides* (Fig. 5). This is a summer deciduous geophyte with flower spikes up to 1 m tall, native to the rocky lime and sandstone hills in the Mediterranean belt of Israel. At the start of the rainy season a rosette of leaves, each 15 to 25 mm wide and up to 25 cm long, is produced. This rosette is a distinctive feature of the plant. Between February and April, the tall flower spike, with 50 to 100 intensely blue flowers, is produced. The plant is cultivated for cut flowers or

as a garden ornamental and for drought-tolerant road-side plantings (Luria, 1991). Hybridization programs with this species have been undertaken.

Borochoy & Luria (1993) tested the control of flowering by cold storage at different temperatures and subsequent cultivation under short or long day photoperiods. Administration of ethylene was also tested. The species was found to be insensitive to these stimuli. The main obstacle for further development of this crop is the limited forcing potential. To overcome this, hybridization with more photoperiod-sensitive species or lines could be attempted.

STERNBERGIA

Though three of the seven species that are known occur in Israel, *Sternbergia clusiana*, the most common among them and no doubt the most attractive and striking, has never before been domesticated. This hysteranthous, yellow, autumn flowering species (with flowers as much as 15 cm long) is almost unknown in the trade. When the flowers of a massive clump

of bulbs burst through the sun-parched soil, their sheer size and brilliant color are an unique attraction, suitable both for garden use as well as container cultivation. Seed propagation is easy with first year germination; however, vegetative reproduction rates are relatively low. Development of a propagation protocol for the species is therefore a precondition for its commercial development.

URGINEA

Urginea maratima, known as maritime squill (Fig. 7), is one of the most outstanding late summer and autumn flowering bulbous plants. It represents the tropical element among the hysteranthous bulbs of Israel (Dafni et al., 1981). The species ranges from the Negev semi-deserts to the Galilee and is common throughout the Mediterranean basin. Locally, it is often dominant in disturbed and grazed areas.

The flowering spike precedes the large leaves, which appear after the first winter rains. The trigger for blooming is the increasing temperature differ-

ential between day and night, starting in the Central Mountain Ridge (late August–September), and ending in the Jordan Valley and the Dead Sea area (November–December). Fruit formation begins at the base of the spike, while the upper flowers are still blooming. Seeds are dispersed with the onset of the rainy season and germinate during the winter, thereby avoiding predation. Flowering starts after 4–5 years of growth from seed. The bulb is the largest among the local geophytes. It splits into halves after 7–8 years, and eventually forms dense clumps. It is protected from predation by a high content of glycosides and



Fig. 6. *Sternbergia clusiana*.



Fig. 7. *Urginea maritima*.

calcium-oxalate raphids, the latter which account for its use in traditional and modern medicines (treating heart diseases, etc.). The thick fleshy scales are covered by a thin, dry tunic. The relatively shallow bulb is tightly fixed in the ground by thick perennial roots. This is why the plant was used by farmers as a boundary marker for property rights. The tall inflorescences are especially prominent at the end of summer when often little else remains just before plowing. It was also used to mark roads by the British in the Coastal Plain, using the reflection from the white inflorescences and glossy leaves. Today it is used as a low maintenance ornamental along newly built highways. Small quantities are also exported to arid and semi-arid parts of the U.S. In horticultural practice it is complementary to the spring flowering *Scilla hyacinthoides*.

Further commercial utilization hinges on the development of rapid bulb production protocols and commercial promotion of the plant as a drought resistant ornamental for arid and semi-arid regions. Extraction of the bioactive compounds from the bulbs can be a side product as well.

DISCUSSION OF FUTURE TRENDS AND PRODUCTS

On the basis of morphological data, systematics, (Zohary and Feinbrun, 1930; Feinbrun-Dothan and Danin, 1991; D. Zohary, 1997), ecology and reproductive cycles (Dafni et al., 1981, 1993), a number of promising candi-

dates for three types of horticultural products could be selected from among native Israeli geophytes: garden plants, cut flowers and for production of flowering pot plants.

For the environmentally minded gardener in seasonal semi-arid environments, East-Mediterranean geophytes promise extra value. Beyond the obvious spring burst of colors, leafless flowering geophytes extend the flowering season with a second flowering peak in summer and autumn, when all other plants in the Mediterranean-type garden are drought-stressed and dormant.

Showy, leafless flowering geophytes are common in Israel (Dafni et al., 1981). Though not unique to this part of the world, they are a dominant element in the Mediterranean and the region's autumn flora. Their convergent ecological evolution from two distinct types of ecosystems (temperate mountain floras and tropical or subtropical grassland floras) makes them compatible with a number of garden niches. These garden habitats, when chosen carefully, will not only support the normal growth and bloom of native geophytes, but will also encourage their rapid increase. Over the years, these plants can become a distinctive feature of any garden.

CONSERVATION AND DOMESTICATION

Although it has often been said that Mediterranean-type ecosystems are the most benign habitats for the life of civilized societies, they have considerably lagged behind the more industrialized temperate countries in terms of horticultural development (both practice and science) in the last two hundred years.

Only in the course of the last forty or fifty years, thanks to an improved standard of living and the rapid development of industry and, especially, mass tourism, this situation is changing. Ecological exploration and an awakening of public consciousness to the sad status of these unique environments engenders deep concern for the future of these natural treasures. While this is true for all of the five so-called Mediterranean-type ecosystems, it is especially true for the ancient historical centers of Mediterranean civilization.

In this area, once the cradle of western culture and science, poor environmental management and warfare have left their mark. Extensive agriculture and overgrazing, as well as industry and urbanization, have profoundly invaded vast natural areas, once densely covered by evergreen woodlands and other unique habitats. This has resulted in loss of habitats and bio-diversity, erosion and environmental degradation. Many species have been brought to the brink of extinction, as the characteristically sensitive Mediterranean envi-

ronment hosts many narrowly distributed species. Many other species reach their southern or the northern distribution limit in this region.

Many of the native species are on the list of rare or threatened species (Oldfield, 1989; Fragman et al., 1999), the trade of which is regulated by CITES and other international conservation agreements for the protection of bio-diversity. Thus their collection from wild populations, as practiced in the past (Campbell, 1989; Read, 1989) to the point of extinction, is now forbidden in Israel. Development of a trade in domesticated, cultivated-origin selections with superior horticultural characteristics should be encouraged by creating a market for them. For rural populations, this could perhaps become a significant economic proposition. Alternatively, this demand could sustain production by specialized foreign growers.

The flower-bulb industry is based on the combined professional knowledge of a selected group of growers, extension, research and marketing specialists. With these human resources available in Israel, it does not seem too optimistic to anticipate that, by the end of this decade, considerable development in Israeli indigenous flower bulb growing will be realized.

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Table 1. Taxonomic and ecogeographical information on native Israeli geophytes.

TAXON	ECOGEOGRAPHIC CHARACTER *	WILD HABITAT	REFERENCES:
<i>Anemone coronaria</i>	MD	Garigues and Batha, fields	Zohary (1966)
'Gadil'			Horovitz et al. (1975)
'Jerusalem'			
<i>Allium</i>			
<i>A. ampeloprasum</i>	MD – IT	Batha, fields, disturbed places	Feinbrun-Danin (1991)
<i>A. aschersonianum</i>	W (IT)	Deserts, steppes	Feinbrun-Danin (1991)
<i>A. neapolitanum</i>	MD	Fields and disturbed habitats	Feinbrun-Danin (1991)
<i>A. nigrum</i>	MD	Fallow fields, maquis, garigue	Feinbrun-Danin (1991)
<i>A. phaneranthrum</i>	MD – W(IT)	Rocks and hard limestone cliffs	Feinbrun-Danin (1991)
<i>A. schubertii</i>	E (MD)	Fields on heavy soils	Feinbrun-Danin (1991)
<i>Cyclamen coum</i>	E(MD)-W(IT)	Rocks in maquis shade, rocky slopes	Feinbrun-Danin (1991)
<i>Cyclamen persicum</i> Wild Types	E(MD)	Rocks, betw. stones and sandy soils	Feinbrun-Danin (1991)
<i>Colchicum hierosolymitanum</i>	E(MD)	Fields, on terra rossa and basalt soil	Feinbrun-Danin (1991)
<i>C. feinbruniae</i>	E(MD)	Batha, stony heavy basalt soil	Feinbrun-Danin (1991)
<i>Fritillaria persica</i>	E(MD)- W(IT)	Maquis edges, garigue, Batha and grassy steppes	Feinbrun-Danin (1991)
Libanotica type			

* E(MD) - East Mediterranean, IT - Irano-Turanian, W(IT) - west Irano-Turanian, MD - Mediterranean, SA - Sharo-Arabian, W (ES) - west Euro-Siberian, W(MD) - West Mediterranean.

Table 1. Continued

TAXON	ECOLOGICAL CHARACTER	WILD HABITAT	REFERENCES:
<i>Hyacinthus orientalis</i>	E(MD)	Maquis and rocky slopes on high mountains	Feinbrun-Danin (1991)
<i>Ixiolirion tataricum</i>	IT	Loessy steppes & tragacanth batha	Feinbrun-Danin (1991)
<i>Iris atropurpurea</i>	E(MD) endemic	Sandy loams & sandstone hills	Feinbrun-Danin (1991)
<i>Iris haynei</i>	E(MD) endemic	Batha on terrarosa and rendzina	Feinbrun-Danin (1991)
<i>Iris hermona</i>	E (MD) endemic	Basalt soil and limestone batha	Feinbrun-Danin (1991)
<i>Iris hortetia</i>	F (MD) endemic	Batha on grassy, stony terra rossa	Feinbrun-Danin (1991)
<i>Iris mariae</i>	W(IT) endemic	Stabilized dunes in semi-desert	Feinbrun-Danin (1991)
<i>Iris vartanii</i>	E (MD)	Batha	Feinbrun-Danin (1991)
<i>Lilium candidum</i>	E (MD)	Shaddy maquis, cracks in rocks	Feinbrun-Danin (1991)
<i>Narcissus tazetta</i> var. <i>chinensis</i>	E(MD)	Moist fields and rocks	Feinbrun-Danin (1991)
<i>Ornithogalum trichophyllum</i>	W(IT) – SA	Semi-desert	Feinbrun-Danin (1991)
<i>Pararatium maritimum</i>	F (MD)	Coastal dunes and sandstones	Feinbrun-Danin (1991)
<i>Paeonia mascula</i>	W (ES), (MD)	Sunny patches in maquis	Feinbrun-Danin (1991)
<i>Ranunculus asiaticus</i>	MD	Batha, fields	Feinbrun-Danin (1991)
<i>Romulea bulbocodium</i>	MD	Batha, heavy soils	Feinbrun-Danin (1991)

Table 1. Continued

TAXON	ECOGEOGRAPHIC CHARACTER	WILD HABITAT	REFERENCES:
<i>Scilla hyacinthoides</i>	N(MD)	Batha, garigue, fields	Feinbrun-Danin (1991)
<i>Sternbergia clusiana</i>	E(MD) W(IT)	Batha, among rocks and steppes	Feinbrun-Danin (1991)
<i>Tulipa polychroma</i>	E(IT)	Steppes	Feinbrun-Danin (1991)
<i>Tulipa systola</i>	W(MD)	Semi-desert and steppes	Feinbrun-Danin (1991)
<i>Urginea maritima</i>	MD	Batha, steppes, deserts among rocks	Feinbrun-Danin (1991)

Table 2. The main commercial indigenous bulb related products in Israel.

TAXON	CHIEF USE	UNITS SOLD	VALUE (\$) *
<i>Allium aschersonianum</i>	Cut flower	100,000	25,000
<i>Allium nigrum</i>	Cut flower	40,000	10,000
<i>Anemone coronaria</i>	Cut flower Garden plant	45,000,000 45,000,000	9,000,000 500,000
<i>Cyclamen coum</i>	Garden plant Pot plant	No data	No data
<i>Cyclamen persicum</i> Wild Types	Garden plant Pot plant	40,000 100,000	100,000 100,000
<i>Fritillaria persica</i>	Garden plant	100,000	150,000
<i>Hyacinthus orientalis</i>	Garden plant Pot plant	12,000 20,000	30,000 20,000
<i>Iris atropurpurea</i>	Cut flower Garden plant	600,000 50,000	20,000 25,000
<i>Ixiolirion tataricum</i>	Garden plant Cut flower Garden plant	No data	No data
<i>Lilium candidum</i>	Cut flower Garden plant	No data	No data
<i>Narcissus heisteria</i> var. <i>Janet's</i>	Cut flower Pot plant Garden plant	4,000,000 30,000 28,000,000	8,000,000 25,000 5,000,000
<i>Pancratium maritimum</i>	Garden plant	No data	No data
<i>Ranunculus asiaticus</i>	Cut flower Pot plant Garden plant	14,000,000 50,000 30,000,000	5,600,000 10,000 1,200,000
<i>Scilla hyacinthoides</i>	Garden plant	100,000	100,000
<i>Urginea maritima</i>	Garden plant	100,000	100,000

* correct for 1994–1995, the last year of available comprehensive export figures

Table 3. Cultivation patterns

TAXON AND VARIETY	PROPAGATION METHOD	STORAGE ORGAN	AGE FROM SEED TO 1 st FLOWERING (YEARS)	MARKETING AGE (YEARS)	MARKETING SIZE (CIRCUMFERENCE, CM.)
<i>Anemone coronaria</i>					
'Gallii'	Seed	Tuber roots	1	2	3
'Ierusalem'	Seed	Tuber roots	1	2	3
<i>Albium</i>					
<i>A. ameloprasum</i>	Brut, Seed	Bulb	3	4	≥ 12
<i>A. aschersonianum</i>	Seed	Bulb	3	4	≥ 12
<i>A. neapolitanum</i>	Brut, Seed	Bulb	2	2	6-4
<i>A. nigrum</i>	Seed	Bulb	3	4	≥ 12
<i>A. phaneranthrum</i>	Brut, seed	Bulb	3	3	10-8
<i>A. schubertii</i>	Brut, seed	Bulb	4	4	10-8
<i>Cyclamen coum</i>	Seed	Hypocotyl corm	3	4	≥ 12
<i>Cyclamen persicum</i> Wild Types	Seed	Hypocotyl corm	3	4	≥ 12
<i>Cochlidium hierosolymitanum</i>	Bulbil/seed	Corm	4	5	7-10
<i>Cochlidium tembrumae</i>	Bulbil/seed	Corm	4	5	8-10
<i>Fritillaria persica</i>	Scale	Bulb	5	6	20-18
Arabica type	Scale	Bulb	5	6	20-18
Lebanonica type	Scale	Bulb	5	6	20-18
<i>Hyacinthus orientalis</i>	Bulbil	Bulb	3	4	14-16
<i>Ixiolirion tataricum</i>	Seed	Bulb	3	4	6-8
<i>Iris section Oncocyclus</i>	Rhizome	Rhizome	2	2	25-30
<i>Iris vartanii</i>	Seed/bulbil	Bulb	3	3	2-4
<i>Lilium candidum</i>	Scale	Bulb	3	3	14
<i>Narcissus tazetta</i> var. <i>chinensis</i>	Bulbils/scale	Bulb	1-2	2-3	≥ 12

Table 3. Continued

TAXON AND VARIETY	PROPAGATION METHOD	STORAGE ORGAN	AGE FROM SEED TO 1 ST FLOWERING (YEARS)	MARKETING AGE (YEARS)	MARKETING SIZE (CIRCUMFERENCE, CM.)
<i>Ornithogalum trichophyllum</i>	Scale	Bulb	1 - 2	2 - 3	≥ 10
<i>Pancreatum maritimum</i>	Seed/Bulbil	Bulb	1 - 2	2 - 3	≥ 14
<i>Paeonia moutan</i>	Seed/Division	Rootstock	3 - 4	4 - 5	≥ 3 buds
<i>Panmulus asiaticus</i>	Seed	Crown	1	1	> 3
<i>Romulea bulbocodium</i>	Seed	Corm	2 - 3	3	≥ 4 - 5
<i>Scilla hyacinthoides</i>	Seed/Scales/Bulbil	Bulb	2 - 3	3	≥ 14
<i>Sternbergia lutea</i>	Bulbil/Scale	Bulb	2 - 3	3 - 4	≥ 8 - 10
<i>Tulipa polychroma</i>	Seed/Bulbil	Bulb	2 - 3	3 - 4	≥ 10 - 12
<i>T. sylvestris</i>	Seed/Bulbil	Bulb	2 - 3	3 - 4	≥ 12 - 14
<i>Urginea maritima</i>	Scales/Bulbils	Bulbs	3 - 4	4 - 5	≥ 20 - 24

Table 4. Cultivation technology of native Israeli geophytes.

Taxon & Variety	Storage Conditions	Forcing Conditions	Planting conditions	Cropping Set-up**			Days to Flowering:
				GH	SH	OF	
<i>Anemone coronaria</i>	25°C dry	30 days at 4°C	Soil at 17°C		+	+	70–90
Galil	25°C dry	30 days at 4°C	Soil at 17°C		+	+	70–90
Jerusalem	25°C dry	30 days at 4°C	Soil at 17°C		+	+	70–90
<i>Allium</i>							
<i>A. ampeoprasum</i>	25°C dry	30 days at 9°C	Soil at 10°C		+	+	
<i>A. aschersonianum</i>	25°C dry				+	+	
<i>A. neapolitanum</i>	25°C dry	30 days at 9°C	Soil at 10°C		+	+	
<i>A. nigrum</i>	25°C dry				+	+	
<i>A. phaneranthum</i>	25°C dry	30 days at 9°C	Soil at 10°C		+	+	
<i>A. schubertii</i>	25°C dry				+	+	
<i>Cyclamen coum</i>	20°C dry	15°C in dark	Soil at 17°C		+	+	30
<i>C. persicum</i>	20°C dry	17°C in dark	Soil at 17°C		+	+	30
<i>Colchicum hierosolymitanum</i>	25°C dry	56 days at 4°C	Soil at 15°C		+	+	330
<i>Fritillaria persica</i>	25°C dry		Soil at 17°C		+	+	150–170
<i>Hyacinthus orientalis</i>	20°C dry	60 days at 2°C	Soil at 15°C		+	+	100
<i>Ixiolirion tataricum</i> (2)	25°C dry		Soil at 17°C			+	100
<i>Iris atropurpurea</i>	30°C dry	30 days at 9°C	Soil at 17°C	+		+	120
<i>I. haynei</i>	30°C dry	30 days at 9°C	Soil at 17°C	+		+	160
<i>I. hermona</i>	30°C dry	30 days at 9°C	Soil at 17°C	+		+	160
<i>I. lortetii</i>	30°C dry	30 days at 9°C	Soil at 17°C	+		+	160
<i>I. mariae</i>	30°C dry	30 days at 9°C	Soil at 17°C	+		+	120
<i>I. varianii</i>	25°C dry	30 days at 9°C	Soil at 17°C	+	+	+	45
<i>Lilium candidum</i>	25°C dry		Soil at 17°C				
<i>L. candidum</i> 'Shosha'		30 days at 9°C	Soil at 17°C		+	+	200
<i>Narcissus tazetta</i> var. <i>chinensis</i>	28°C dry	Delay at 30°C	Soil at 17°C			+	30
<i>Ornithogalum trichophyllum</i>	25°C dry		Soil at 17°C			+	150–160
<i>Pancreatum maritimum</i>	25°C dry		Soil at 15°C			+	240–280
<i>Paeonia mascula</i>	4°C moist	40 cold units*	Soil at 10°C	+	with shading	+	60 after forc.
<i>Ranunculus asiaticus</i>	25°C dry	30 days at 4°C	Soil at 15°C	+		+	70
<i>Romulea bulbocodium</i>	25°C dry		Soil at 17°C			+	130
<i>Scilla hyacinthoides</i>	25°C dry		Soil at 17°C		+	+	150
<i>Sternbergia clusiana</i>	25°C dry		Soil at 15°C		+	+	300
<i>Tulipa polychroma</i>	25°C dry	60 days at 4°C	Soil at 15°C		+	+	60
<i>T. systola</i>	25°C dry	60 days at 4°C	Soil at 15°C		+	+	60
<i>Urginea maritima</i>	25°C dry		Soil at 15°C			+	300

** GH = greenhouse, SH = shade structure, OF = open field.

Table 5. Phytopathological characteristics of Israeli geophytes.

TAXON & VARIETY	PHYSIOLOGICAL DISORDER	BACTERIAL SUSCEPTIBILITY	FUNGAL SUSCEPTIBILITY	VIRAL SUSCEPTIBILITY	OTHERS
<i>Anemone coronaria</i>	Zaetaria syn.		Colletotrichum acutatumRust	C.M.V., T.S.W.V	
<i>Allium</i>		Ervinia	Rust	Virus complex	
<i>Cyclamen coum</i>			Diplodia in store		
<i>Fritillaria persica</i>				Virus complex	
<i>Hyacinthus orientalis</i>		Ervinia, Xantomonas	Rizoctonia		
<i>Ixiolirion tataricum</i>					
<i>Iris</i> sect. <i>Oncocyclus</i> , spp. & hybrids		Pectobacterium		Virus complex	
<i>Lilium candidum</i>			Verticillium, Fusarium	Virus complex	
<i>Narcissus tazetta</i> var. <i>chinensis</i>				Virus complex	Nematodes
<i>Paeonia moutan</i>			Botrytis		
<i>Ranunculus asiaticus</i>		Pseudomonas	Sclerotinia	Virus complex	
<i>Tulipa polychroma</i>				Virus complex	
<i>T. systola</i>				Virus complex	

Table 6. Harvest characteristics of Israeli geophytes.

TAXON & VARIETY	PRODUCT TYPE		HARVEST TIME		HARVEST CONDITIONS	
	FLOWER	STORAGE ORGAN	FLOWER	STORAGE ORGAN	FLOWER	STORAGE ORGAN
<i>Anemone coronaria</i>						
Galil	+	Corm	Bud colored	When dry	2-4°C	25°C dry
Jerusalem	+	Corm	Bud colored	When dry	2-4°C	25°C dry
<i>Allium</i>						
<i>A. ampeloprasum</i>	+	Bulb	1 st inflorescence	When leaves dry	2-4°C	25°C good ventilation
<i>A. aschersonianum</i>	+	Bulb	1 st inflorescence	When leaves dry	2-4°C	25°C good ventilation
<i>A. neapolitanum</i>	+	Bulb	1 st inflorescence	When leaves dry	2-4°C	25°C good ventilation
<i>A. nigrum</i>	+	Bulb	1 st inflorescence	When leaves dry	2-4°C	25°C good ventilation
<i>A. phaneranthum</i>	+	Bulb	1 st inflorescence	When leaves dry	2-4°C	25°C good ventilation
<i>A. schubertii</i>	+	Bulb	1 st inflorescence	When leaves dry	2-4°C	25°C good ventilation
<i>Colchicum hierosolymitanum</i>	+	Corm		When leaves dry		25°C good ventilation
<i>Cyclamen coum</i>		Corm	Full color	When leaves dry	2-4°C	25°C in dark
<i>C. persicum</i>		Corm	Full color	When leaves dry	2-4°C	25°C in dark
<i>Fritillaria persica</i>		Bulb	1 st flower open	When leaves dry	2-4°C	25°C good ventilation
Arabica type	+	Bulb	1 st flower open	When leaves dry	2-4°C	25°C good ventilation
Libanotica type	+	Bulb	1 st flower open	When leaves dry	2-4°C	25°C good ventilation
<i>Hyacinthus orientalis</i>		Bulb		When leaves dry		25°C good ventilation
<i>Iris Sect. Oncocylus</i>	+	Rhizome	Emergent Color	End of summer	2-4°C	25°C good ventilation
<i>Iris variana</i>	+	Bulb		When leaves dry		25°C good ventilation
<i>Ixiolirion tataricum</i>		Bulb		When leaves dry		25°C good ventilation
<i>Lilium candidum</i>		Bulb		8 week after flowering		25°C good ventilation
<i>Narcissus tazetta</i> var. <i>chinensis</i>	+	Bulb	1 st flower open	When leaves dry	2-4°C	28°C good ventilation
<i>Ornithogalum trichophyllum</i>		Bulb		When leaves dry		25°C good ventilation
<i>Pancratium maritimum</i>		Bulb		8 weeks after flowering		25°C good ventilation
<i>Paeonia mascula</i>		Roots		When leaves dry	2-4°C moist storage	
<i>Ranunculus asiaticus</i>	+	Root-Crown	Flower open	When leaves dry	2-4°C	28°C good ventilation

Table 6. Continued

TAXON & VARIETY	PRODUCT TYPE		HARVEST TIME		HARVEST CONDITIONS	
	FLOWER	STORAGE ORGAN	FLOWER	STORAGE ORGAN	FLOWER	STORAGE ORGAN
<i>Romulea bulbocodium</i>		Corm		When leaves dry		28°C good ventilation
<i>Scilla hyacinthoides</i>	+	Bulb	1 st flower open	When leaves dry	2-4°C	25°C good ventilation
<i>Sternbergia clusiana</i>		Bulb				
<i>Tulipa polychroma</i>	+	Bulb	Flower color change	When leaves dry	2-4°C	Bimodal 25°C long 20°C 60 d.
<i>T. systela</i>	+	Bulb	Flower color change	When leaves dry	2-4°C	Bimodal 25°C long 20°C 60 d.
<i>Urginea maritima</i>		Bulb	1 st flower open	When leaf dry		28°C good ventilation

Table 7. Economic significance of some Israeli geophytes.

TAXON & VARIETY	PRODUCTION AREA (DUNAM=1000 SQM)	
	FLOWERS	BULBS
<i>Anemone coronaria</i>	420	300
<i>Allium</i>		
<i>A. ampeloprasum</i>	10	5
<i>A. aschersomanum</i>	5	10
<i>A. neapolitanum</i>	1	1
<i>A. nigrum</i>	35	10
<i>A. schubertii</i>		3
<i>Colchicum hierosolymitanum</i>		0.5
<i>Cyclamen coum</i>		0.25
<i>Cyclamen persicum</i>	1	20
<i>Fritillaria persica</i>		9
<i>Hyacinthus orientalis</i>		10
<i>Isotria medeoloides</i>		3
<i>Iris Oncocyclus hybrids</i>	20	40
<i>Iris sibirica</i>		0.5
<i>Lilium candidum</i>		20
<i>Narcissus tazetta</i> var. <i>chinensis</i>	3	10
<i>Pancratium maritimum</i>		30
<i>Ranunculus asiaticus</i>	200	400
<i>Scilla hyacinthoides</i>		50
<i>Urginea maritima</i>		20

ULTRAVIOLET REFLECTANCE PATTERNS IN SOME AGAPANTHACEAE, ALLIACEAE AND AMARYLLIDACEAE AND THEIR POSSIBLE SIGNIFICANCE FOR POLLINATION¹

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ABSTRACT

Flowering specimens of Agapanthaceae (1 genus; 2 species), Alliaceae (3 genera; 6 species) and Amaryllidaceae (13 genera; 18 species) were photographed in late summer and early autumn in full sunlight to produce Human visual spectrum (HVS) and UV images for each flower to allow direct comparison of their reflectance patterns. The results showed that there were clear differences between genera, and in some cases, species within genera in terms of the UV reflectance patterns displayed. The patterns seen varied from no HVS or UV contrast or reflectance pattern (e.g. *Cyrtanthus*, *Hippeastrum*, *Nothoscordum* and *Sprekelia*) or UV-absorptive but 'shiny' (e.g. *Allium*, *Calostemma* and some *Crinum*) to variously UV-contrasting (most taxa). In particular, *Clivia* and some *Hymenocallis* and *Ismene* spp. showed strong UV-reflectance patterns, possibly to assist in the recognition of these flowers by their pollinators under shade or low light. There were clear UV patterns in many taxa regarded as nocturnally pollinated, suggesting that UV-reflectance in moonlight may be important, in contrast to a previous study on hawkmoth-pollinated flowers. *Hymenocallis* in particular showed clear, species-specific UV patterns suggesting that these may assist in pollinator fidelity under night pollination, and that further study is needed to elucidate the importance of such patterns in the Alliaceae Alliance.

INTRODUCTION

Color and visual perception varies considerably between different organisms, and this can affect the way in which blossoms present for pollinators (Faegri and van der Pijl, 1979). In particular, many organisms are able to perceive ultraviolet reflectance (Kevan et al., 2001), including bees, Lepidoptera (Brunton and Majerus, 1995) and birds (Goldsmith, 1980;

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Burkhardt and Maier, 1989; Bennett and Cuthill, 1994). Although the ability to see UV reflectance is widespread and possibly ancient, (in fact the absence in humans appears to be more the exception rather than the rule), it represents only part of the overall color spectral response and must be viewed in the context of total color perception and biology of the target viewers (Kevan et al., 2001). For example, shiny surfaces attract inexperienced pollinators (Kugler, 1942) and some flowers which appear matt in the human visual spectrum (HVS) are shiny in the UV. Similarly, it has been shown that floral contrast attracts bees (Proctor et al., 1996), so that non-UV flowers with a strong HVS contrast can still be visible to a bee or other UV-sensitive pollinator.

Amaryllidaceae and Agapanthaceae, although generally regarded as related separate families (e.g. Kubitzki, 1998) have recently been included within an expanded Alliaceae (AGP II, 2003) as they represent a single evolutionary lineage. For the purposes of discussion in this paper, the three family names will be used. Amaryllid pollination varies widely, with numerous temperate species bee-pollinated (Knuth, 1909), whereas many of the large, brightly colored tropical taxa are ornithophilous, and some red-flowered African taxa are butterfly-pollinated (Meerow and Snijman, 1998; Manning et al., 2002). In contrast, those genera with white, often crateriform flowers, narrow tepals and versatile anthers are considered to be characteristic of hawk-moth (Sphingidae) pollination (Morton, 1965; Grant, 1983), although on islands where pollinator choice is limited, lizard pollination can occur (Perez-Mellado et al., 2000). In contrast, the majority of Alliaceae form more generalist landing-platform umbels which are bee-, beetle-, butterfly- or fly-visited (Rahn, 1998), whereas *Agapanthus* is both bird and bee-pollinated (Leighton, 1965; Manning et al., 2002).

Nevertheless, because there is a general lack of detailed pollination information for the Amaryllidaceae (Meerow and Snijman, 1998; Manning et al., 2002), the aim of this preliminary study was to see if UV reflectance patterns are widespread within the group and/or constant within genera, given that both Amaryllidaceae and Liliaceae (sens. lat.) were regarded as UV 'rich' families by Guldberg and Atsatt (1975). In particular, given that UV patterns are only a small part of the overall pollination syndrome for the flowers (Kevan et al., 2001), the study aimed to see how, if at all, any patterns might relate to apparent pollination syndromes within the Amaryllidaceae/Alliaceae alliance.

MATERIALS AND METHODS

Flowering specimens of Agapanthaceae (1 genus; 2 species), Alliaceae (3 genera; 6 species) and Amaryllidaceae (11 genera; 14 species) growing in the Adelaide Botanic Gardens, the Anstey Hill Recreation Reserve in suburban Adelaide, the campus of the University of Adelaide or cultivated by the author were collected in late summer and autumn of 2004. Flowers were photographed in full sunlight between 10 am and 4.00 pm either *in situ* or with a black cardboard background using a Sony Mini DCR-TRV900E video camera, using the still photograph, auto-focus and auto-exposure options, both with and without a Hoya U360 filter. This produced paired color HVS and UV images for each flower allowing direct comparison of their reflectance patterns.

Because the UV images produced in this matter, although clearly visible, were nevertheless very dark, the digital images were transferred to computer and enhanced using the Enhance Auto Levels [brightness and contrast enhancement] option in Adobe® Photoshop® Elements. This resulted in high quality images with good visual contrast for comparison with the HVS images.

RESULTS

The blossoms examined in this study fell into several different patterns based on whether they showed HVS and/or UV contrast and to what degree (Table 1). Within both Agapanthaceae spp. there was clear contrast on the tepals with both HVS and UV distinction of the central vein (Figs 1, A1-B2). Alliaceae, although lacking strong HVS contrast showed good UV contrast in both the violet (Figs 1, H1-2) and white (Figs 1, G1-2) *Tulbaghia* spp. examined. The two white *Allium* spp. were UV absorptive albeit 'shiny' (Figs 1, C1-D2), whereas those for both white *Nothoscordum* spp. were non-reflective (Figs 1, E1-2).

The Amaryllidaceae were very variable, reflecting the range of floral forms and syndromes exhibited between the different species studied. *Cyrtanthus* (Figs 2, G1-2), showed no strong contrasting HVS or UV patterns whereas *Leucojum* (Figs 3, D1-2) was HVS contrasting but not in the UV, while *Calostemma* (Figs 2, C1-2) and *Crinum* (Figs 2, F1-2) were UV 'shiny'. The flowers or blossoms of *x Amarygia* (Figs 2, A1-2), *Amaryllis* (Figs 2, B1-2), *Haemanthus* (Figs 2, H1-2), *Narcissus* (Figs 3, E1-2) and *Zephyranthes* (Figs 3, F1-2) all exhibited varying degrees of the common, so-called bull's-eye or target UV patterning (Rorslett, 2003) with absorption



Fig. 1. Visual (1) and UV (2) patterns of some late summer and autumn-flowering Agapanthaceae and Alliaceae. A: *Agapanthus africanus*; B: *A. praecox* subsp. *orientalis*; C: *Allium tuberosum*; D: *A. vineale*; E: *Nothoscordum bivalve*; F: *N. inodorum*; G: *Tulbaghia cominsii*; H: *T. violacea*.

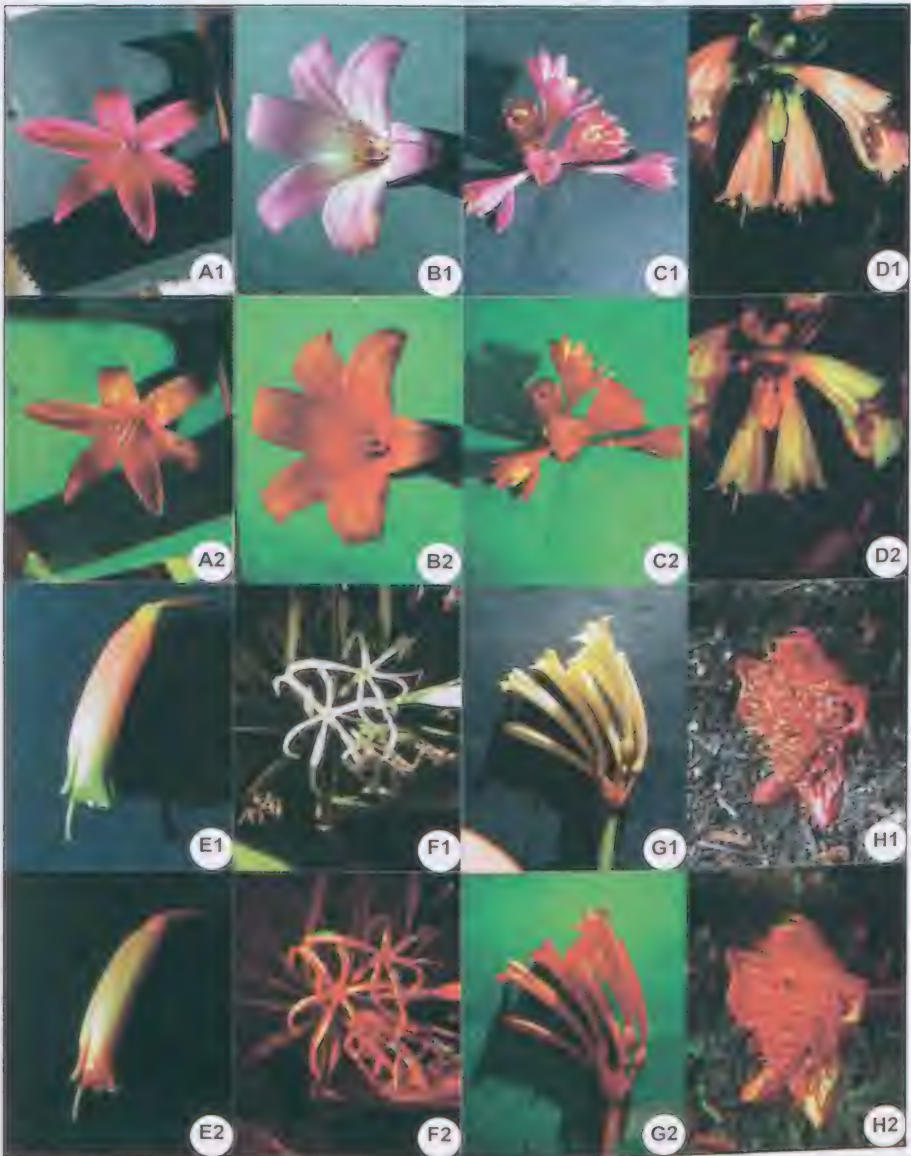


Fig. 2. Visual (1) and UV (2) patterns of some late summer and autumn-flowering Amaryllidaceae. A: *x Amarygia parkeri*; B: *Amaryllis belladonna*; C: *Calostemma purpurea*; D: *Clivia x crysanthiflora*; E: *C. gardenii*; F: *Crinum asiaticum*; G: *Cyrtanthus ochroleucus*; H: *Haemanthus coccineus*.

and reflectance varying between the outer and inner parts of the tepals. The two *Clivia* species studied (Figs 2, D1-E2), on the other hand, were very strongly UV reflective as a whole, making a clear contrast with surrounding vegetation in both the HVS and UV.

Although all three taxa of the closely related genera *Hymenocallis* and *Ismene* possess uniformly white HVS flowers with yellowish anthers, they showed very different UV patterns. Those of *I. narcissiflora* were uniformly absorptive, with only some shininess (Figs 3, C1-2), while those of *I. x festalis* were strongly UV reflective in both the corolla and corona, but with absorptive anthers (Figs 3, A1-2). *H. littoralis* (Figs 2, B1-2) was intermediate between these extremes, with an absorptive, slightly shiny perianth but a reflective corona, except for the anther filaments, which were absorptive, creating a 'star' effect and accentuating the center of the flower.

DISCUSSION

There is a considerable body of literature relating floral shape, color, nectar, scent and other characteristics into broad syndromes for particular pollinator classes (e.g. Kugler, 1963; Faegri and van der Pijl, 1979; Vogel, 1998a; Ramírez, 2003). There is some evidence that these patterns of floral shape and syndromes can be related to percentages of visitation (Kugler, 1963; Ramírez, 2004), although almost all flowers can show an ability to use a wider range of pollinators than their expressed syndrome would necessarily predict (Waser et al., 1996; Ramírez, 2004).

The Alliaceae include members which have syntepaly, both wet and dry stigma types, protandry and protogyny, septal and possibly androecial nectaries, and variously cleistogamous (self-pollinating), allo- (generalist), melitto- (bee) and sphingophilous (hawkmoth) or phalenophilous (butterfly) flowers Vogel (1998a). Nevertheless, most members of the family show generalist pollination syndromes by small insects (bees, flies, flower-beetles, wasps, etc.) with the umbel acting as a simple landing platform (Knuth, 1909; Manning et al., 2002) and nectar readily accessible from septal ducts in the ovary (Vogel, 1998b).

The *Allium* and *Nothoscordum* species in this study were all UV absorptive, although the two *Allium* species examined were nevertheless shiny. This contrasts with the statement by Shmida and Dafni (1989) that white-flowered *Allium* were "notable as having high UV color." Unfortunately, as they refer in that paper to an apparently never-published manuscript, it is not possible to know which *Allium* species they studied, and whether shiny



Fig. 3. Visual (1) and UV (2) patterns of some late summer and autumn-flowering Amaryllidaceae. A: *Ismene x festalis*; B: *Hymenocallis littoralis*; C: *Ismene narcissiflora*; D: *Leucojum aestivum*; E: *Narcissus tazetta* cv.; F: *Zephyranthes candida*.

flowers were counted as UV 'reflective'. Flowers which are UV shiny would in any case tend to make sense for plants with generalist composite dish-bowl blossoms such as *Allium*, as naïve pollinators are attracted to shiny surfaces (Kugler, 1942).

In contrast, both of the *Tulbaghia* spp. examined, although more or less monochromatic in the HVS, nevertheless showed good UV contrast. Mauve-flowered *Tulbaghia* spp. are thought to be mainly butterfly- and bee-pollinated whereas the white flowered spp. are moth-pollinated (Manning et al., 2002), and this would support the hypotheses that the flowers provide contrast for diurnal and nocturnal pollinators respectively which are capable of discerning UV and which respond better to flowers where there is a visual contrast.

Flowers in Agapanthaceae are syntepalous and zygomorphic (by anther filament twisting) with septal nectaries, and are classed as showing melitto-, psycho- (moth) and/or ornithophilous (bird) pollination syndromes (Vogel, 1998a). Those *Agapanthus* spp. with spreading flowers are thought to be mainly bee-pollinated (Manning et al., 2002) although cultivated specimens in Adelaide were also visited by Hesperidae (Skippers).

Amaryllidaceae show a very wide range of pollination strategies often both between and within genera (Manning et al., 2002). The flowers are often syntepalous and zygomorphic, with both wet and dry stigma types, protandry, heterostyly, septal nectaries or pollen as the main reward and variously melitto-, phalaeno-, psycho-, ornitho-, chiroptero- (bat) and sphingophilous flowers (Vogel, 1998a).

Leucojum is reportedly pollinated by honeybees, and *Narcissus* by Lepidoptera and Anthophorid bees (Knuth, 1909), and in both cases there is generally good HVS contrast, but little or no UV differentiation. The flowers of *N. tazetta* did show some slight contrast between the corona and the surrounding perianth, which may further assist the pollinator in locating the access point to the nectaries. Rørslett (2003) reported that the flowers of *N. pseudonarcissus* showed unusual irregular longitudinal striping in the UV, and this may be another example of a 'shiny' UV absorptive flower for naïve pollinators.

The capitulate blossoms of red *Haemanthus* are regarded as bird-pollinated (Manning et al., 2002), and although the flowers were UV absorptive they were shiny, making a clear contrast to the matt substrate, as well as contrasting with the intermediately UV reflective subtending involucre bracts. The absence of leaves at anthesis in this genus possibly also assists in making the flowers stand out from their surroundings, both in the HVS and UV. In con-

trast, the orange flowers of the nodding, bell-shaped *Clivia* species are also bird pollinated (Manning et al., 2002), but showed strong UV contrast. Similarly, the patent, butterfly-pollinated funnel-shaped flowers of *C. miniata* (both orange and yellow forms) were also strongly UV reflective and contrasting between the tepals and anthers. Flowers of shade-loving plants which are pale against their background are considered to be more easily spotted by pollinators (Shmida and Dafni, 1989), and although this theory generally refers to white flowers, it may also apply to UV reflective shade-growers like *Clivia*, potentially making a stronger visual contrast for their avian pollinators which can see both the orange HVS and pale UV reflection patterns.

Amaryllis belladonna is pollinated by Noctuid moths and less-so by carpenter bees (Manning et al., 2002), and the flowers of \times *Amarygia*, although a man-made hybrid, also fall into the same syndrome as the other brightly-colored southern African Amaryllideae. In these flowers there is both HVS and to some extent UV contrast, with the central regions of the tepals strongly absorptive relative to the intermediately-reflective outer portions. Although generally considered to be a diurnal feature, UV reflectance can also occur under moonlit conditions, and Sphingid moths at least possess trichromatic color receptors for green, violet and UV (Bennett and Brown, 1985). *Zephyranthes* is an entomophilous genus with largely unspecialised allophilous flowers (Broyles and Wyatt, 1991), but the flowers of *Z. candida*, although white, still display a weak form of the 'bull's-eye' UV pattern suggesting that there is some degree of specialisation for pollinators which can discern this part of the visual spectrum.

Crinum is mainly hawkmoth-pollinated (Miyake et al., 1998; Manning and Snijman, 2002). Sphingophilous flowers generally have nocturnally fragrant, long-tubed, pale-colored flowers with abundant nectar and are represented in southern Africa Amaryllidaceae by species of *Crinum*, *Cyrtanthus* and *Pancratium* (Manning and Snijman, 2002). In contrast, the more brightly-colored pink or red-striped Amaryllidaceae with wide trumpet-shaped flowers, are more likely to be diurnally pollinated by a suite of generalist insect pollinators and/or possibly by noctuid moths (Manning et al., 2002), whereas in southern Africa red flowers are visited by sunbirds and/or the specialist Satyrid butterfly known as the Pride of Table Mountain (*Aeropetes tulbaghia*). The large, funnel-shaped flowers of *Hippeastrum* spp. and *Sprekelia* are visited and thought to be pollinated by hummingbirds (Dahlgren et al., 1985; Meerow and Snijman, 1998), but in both taxa, although the flowers are conspicuous in the HVS, there was no UV reflectance.

The different UV patterns seen among the one *Hymenocallis* and two *Ismene* were unexpected, as UV-reflective white flowers are rare (Kevan, 1983; Chittka et al., 1994). White et al. (1994) studied hawkmoth flowers and found that UV backlighting of UV-negative flowers interfered with visitation, but there have been no studies to date using UV-reflective flowers, possibly because the majority of white flowers studied so far do not show ultraviolet reflectance. This phenomenon of non-UV white flowers is generally explained by the fact some bees (and thus by extension other insects) show poor ability to find white or UV-reflective flowers (Spaethe et al., 2001), although other studies have shown that they are able to distinguish them from the green of surrounding foliage (Vorobyev et al., 1999). The presence of strong species-specific UV-patterns in *Hymenocallis* suggests that it may be used by hawkmoths to not only locate, but also potentially to differentiate between different flower species, and would certainly be in the interest of the plants to reduce the chances of hybridization.

Studies of tropical floras have also found that a number of primarily moth-pollinated nocturnal flowers also continue to present and reward diurnally (Ramírez, 2004), allowing for secondary pollination by butterflies and birds, which tend to utilise similar floral syndromes (Proctor et al., 1996). As a result, *Hymenocallis* and *Ismene* flowers might be more visible to both day and night-flying pollinators with UV perception, and because there appear to be differences in patterns between species, there is the option for improved pollinator fidelity through UV-related pattern recognition. This agrees with the model proposed by Waser et al. (1996) that begin at least in part a generalist is a good evolutionary strategy, and may help to explain why these species show different responses in the UV.

CONCLUSIONS

Overall, the Alliaceae Alliance display considerable variation in UV patterning despite a relatively simple and generally similar floral ground plan. This is not really surprising given the wide range of pollinators used with the complex, and it seems that the degree of UV pattern development may be tied to the degree of pollinator specialization, at least in part.

Flowers with more generalist strategies and wide ranges of pollinators tended to be either UV-negative, or to be UV-shiny, supporting the idea of less-adapted pollinator responses. What was less expected was the presence of UV patterning in a number of flowers generally regarded as being nocturnally pollinated, suggesting that moon-reflected UV may indeed be used by pollinators, apparently in contrast to the study of White et al. (1994).

What this present study highlights is the need for detailed studies of the pollination biology of the Alliance, particularly in relation to the visual spectra utilised by the pollinators. The Alliance are clearly rich in UV-reflective flowers, as reported by other studies, but the evolutionary significance of these patterns in relation to both the HVS responses of the flowers as well as other attractants and to any co-evolutionary patterns with pollinators still represents a major field of exploration. This is particularly the case in large and/or widespread genera where there is clearly a range of strategies in place to utilise different pollinators to reduce problems of hybridisation and to improve pollinator fidelity, as well as those with brightly-colored, showy, and/or well-displayed flowers with contrasting HVS patterns or centers, such as *Leucocoryne*.

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Table 1 Human visual spectrum (HVS) and UV reflectance patterns of some late summer- and autumn-flowering Agapanthaceae, Alliaceae and Amaryllidaceae in Adelaide, South Australia. A: anthers; B: floral subtending bracts; P: perianth; ADBG: Adelaide Botanic Gardens; AHRR: Anstey Hill Recreation Reserve; ADU: University of Adelaide research herbarium.

TAXON	FIGURES	SOURCE	BLOSSOM CLASS	HVS COLORS	HVS CONTRAST	UV REFLECTANCE	UV CONTRAST
AGAPANTHACEAE							
<i>Agapanthus africanus</i>	1A1-2	ADBG 874192	Funnel	P: blue, striped; A: blue	Y	P: reflective with absorptive central stripe	Y
<i>A. praecox</i> subsp. <i>orientalis</i>	1B1-2	ADBG 874919	Funnel	P: blue, striped; A: blue	Y	P: reflective with absorptive central stripe	Y
ALLIACEAE							
<i>Allium tuberosum</i>	1C1-2	ADBG 842224	Composite Dish/Bowl	P: white; A: yellow	N	Whole flower absorptive, shiny	slight
<i>Allium vineale</i>	1D1-2	ADBG 981371	Composite Dish/Bowl	P: white; A: yellow	N	Whole flower absorptive, shiny	slight
<i>Nothoscordum Bichthae</i>	1E1-2	ADBG 20011959	Composite Dish/Bowl	P: white; A: yellow	N	Whole flower absorptive	N
<i>N. inodorum</i>	1F1-2	ADBG adventive	Composite Dish/Bowl	P: white; A: yellow	N	Whole flower absorptive	N
<i>Tulbaghia cominsii</i>	1G1-2	ADBG 885986	Trumpet	P: white; A: white	N	P: reflective; A absorptive	Y
<i>T. violacea</i>	1H1-2	ADBG 860181	Trumpet	P: purple; A: purple	N	P: reflective; A absorptive	Y

Table 1 Continued

TAXON	FIGURES	SOURCE	BLOSSOM CLASS	HVS COLORS	HVS CONTRAST	UV REFLECTANCE	UV CONTRAST
AMARYLLIDACEAE							
<i>x Amaryxia parkeri</i>	2A1-2	ADBG 890755	Funnel	P: red-purple, center darker; A: red-purple	weak	P: intermediate, center strongly absorptive	Y
<i>Amaryllis belladonna</i>	2B1-2	ADBG 875010	Funnel	P: pink, center white/yellow; A: yellow	Y	P: intermediate, center strongly absorptive	Y
<i>Calostemma purpurea</i>	2C1-2	AHRJ JGC 1518 (ADU)	Funnel	P: pink-purple; A: yellow	N	Whole flower absorptive, slightly shiny	slight
<i>Clivia x cyrtanthiflora</i>	2D1-2	ADBG 875738	Funnel	P: orange; A: yellow	N	P: strongly reflective, A absorptive	Y
<i>C. gardenii</i>	2E1-2	Cult JGC	Funnel	P: orange, tips green; A yellow	Y	P: strongly reflective, tips and A absorptive	Y
<i>C. miniata</i>	-	Cult JGC	Funnel	P: orange, tips green; A yellow	Y	P: strongly reflective, tips and A absorptive	Y
<i>C. miniata 'Aurea'</i>	-	Cult JGC	Funnel	P: orange, tips green; A yellow	Y	P: strongly reflective, tips and A absorptive	Y
<i>Crinum asiaticum</i>	2F1-2	ADBG 875894	Tube	P: white; A: purple/yellow	N	Whole flower absorptive, slightly shiny	slight
<i>Crinum mauritanicum</i>	-	ADBG 874319	Tube/Funnel	P: white; A: purple/yellow	N	Whole flower absorptive	N

Table 1 Continued

TAXON	FIGURES	SOURCE	BLOSSOM CLASS	HVS COLORS	HVS CONTRAST	UV REFLECTANCE	UV CONTRAST
<i>Crotaphytus alfredensis</i>	2A1-2	ADBG 876064	Trumpet	P: cream; A: yellow	N	Whole flower absorptive	N
<i>Hammaranthus coccineus</i>	2H1-2	ADBG 880790	Composite Dish/Bowl	B: red; P: red; A: yellow	Y	B intermediate; flowers absorptive but shiny	Y
<i>Hippocastanum vitifolium</i>		ADBG 884902	Funnel	P: orange-red; white striped; A: yellow	Y	Whole flower absorptive	N
<i>Homocaulis littoralis</i>	4B1-2	ADBG 881551	Tube/Funnel	P: white; A: orange	N	Corolla strongly reflective; P: and A absorptive	Y
<i>Ipomoea macrocarpa</i>	3C1-2	ADBG 880999	Tube/Funnel	P: white; A: yellow	N	Whole flower absorptive, slightly shiny	N
<i>Ipomoea x fetalis</i>	3A1-2	ADBG 880998	Tube/Funnel	P: white; A: yellow	N	P and corolla strongly reflective; A absorptive	Y
<i>Leucogonum aestivum</i>	3D1-2	ADBG 881231	Campulate Funnel	P: white with green tips; A: yellow	weak	Whole flower absorptive	N
<i>Narcissus tazetta cv</i>	3F1-2	ADBG 881482	Tube/Funnel	P: white; corolla yellow; A: yellow	Y	P: absorptive; corolla strongly absorptive	Y
<i>Sprekelia formosissima</i>		ADBG 882132	Funnel	P: deep red; A: yellow	N	Whole flower absorptive	N
<i>Zapolyanthus candida</i>	3F1-2	ADBG 882148	Dish/Bowl	P: white; center yellow; A: yellow	weak	Outer P lobes absorptive; inner less so, center strongly	Y

THREATENED AMARYLLIDACEAE OF SOUTH AFRICA

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INTRODUCTION

One of the major issues facing humankind today is the future survival of Earth's living things—the myriad forms of life that have shaped our world and which stabilize our planet's intricate global ecosystem. Arising from this concern, Sir Peter Scott, in the 1960's, conceptualised the means to record the state of Earth's biodiversity primarily through the publication of Red Lists of species believed to be at risk of global extinction (Magin *et al.* 1994). Over the years increasing numbers of organisms have been assessed and several improvements to the methods for highlighting those species under threat have been made. As recently as 2001 the World Conservation Union (IUCN) issued new quantitative criteria for assessing the risk of extinction, and these have been globally accepted.

Despite increasing media reports about the world's growing numbers of threatened species, the plight of individual species often continues to be overlooked. Even those in the family Amaryllidaceae, whose exceptional beauty has enchanted horticulturists and gardeners since the 18th century, seldom evoke concern. In many parts of the world this arises from insufficient knowledge about the conservation status of species, however, in regions where the information is available it is often poorly reported. In South Africa, species of Amaryllidaceae have been included in regional Red Data Books since 1980 but these data have remained poorly publicized and have made little impact on species conservation. By drawing attention here to the most recent Red Data assessments of the South African Amaryllidaceae, we aim to raise an awareness of the plight of many of the species and to highlight the encouraging new efforts being made to secure their future.

RED DATA ASSESSMENTS

The first Red Data List for southern Africa, published in 1980 (Hall *et al.* 1980), was followed 16 years later by a long-needed update in which the Red Data assessments listed 114 South African taxa of the Amaryllidaceae (Hilton-



Fig. 1. *Cyrtanthus leptosiphon*, Swellendam district, Western Cape, South Africa.

Taylor 1996). Since then a new system with improved methods of assessing extinction rates of taxa based on quantitative criteria has gained acceptance (IUCN 2001). The aim of the new system is to select taxa that are facing a high probability of extinction in the short or medium term. It differs from the old method of assessing extinction risk in that rarity is not accounted for in the absence of decline or potential decline, and as a result there is no equivalent to the old "Rare" category except in special circumstances. For this reason, Victor & Keith (2004) introduced the Orange List concept and proposed a quantitative system of assessing, recording and documenting

taxa that should be considered for legal protection and conservation. The Orange List consists of taxa that are rare but not declining, as well as taxa that are declining but too widespread to meet the IUCN Red List criteria. Two other IUCN (2001) categories that fall into the Orange List are Data Deficient (DD) and Near Threatened (NT) taxa (for definitions see Appendix 1). In this way, the Orange List will be useful in determining species of "special concern" that should be protected according to South Africa's new Biodiversity Act (National Environmental Management: Biodiversity Bill 2003).

Data on the geographical distributions of the southern African Amaryllidaceae were compiled by Dee Snijman from South African herbarium records (BOL, GRA, NBG, NH, PRE, SAM) and about 20 years of field work, mostly in the winter-rainfall area of South Africa. Other botanists who have contributed field notes are Mr. Tony Dold and Dr. Robert Archer. About 8000 records from critically determined herbarium material were collated for the assessments of risk as part of a broader study of the systematics of the Amaryllidaceae.

In the process of re-assessing the Amaryllidaceae according to the new IUCN criteria, both Red List and Orange List status were considered. Every taxon was assessed and 129 taxa are now Red Data listed (Table 1). All the taxa are endemic to southern African (South Africa, Lesotho, Swaziland, Namibia and Botswana), so their red data assessments are also globally applicable, except *Crinum acaule*, which extends from South Africa to Mozambique. The assessments have been evaluated by southern Africa's Red List authority at the South African National Biodiversity Institute, Pretoria, and will be submitted to the IUCN.

RESULTS

According to the new IUCN assessments there are now 38 taxa of the Amaryllidaceae in categories of threat i.e. Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) in comparison with 25 taxa in the equivalent categories of Endangered (E) and Vulnerable (V) given by

Hilton-Taylor (1996), (see Appendix 1). In addition, there are now 66 taxa on the Orange List, i.e. DD, NT, Critically Rare (RC), Rare (RR), Sparse (RS) and Declining (D). Furthermore, 26 taxa do not qualify for either a category of threat or an Orange List category and are therefore listed as Least Concern (LC). Two species, *Brunsvigia gydobergensis* and *Gethyllis latifolia*, which were formerly listed by Hilton-Taylor (1996) as Extinct (Ex), are no longer thought to be so. *Brunsvigia gydobergensis* is considered a local form of the widespread *Brunsvigia josephi-nae*, and *Gethyllis latifolia* a form of the widespread



Fig. 2. *Amaryllis paradisicola*, Richtersveld National Park, Northern Cape, South Africa.

Gethyllis ciliaris. Since the genus *Gethyllis* is still under revision, *G. latifolia* has been listed as DD until more information can be gathered to determine its true taxonomic and IUCN status.

THREATS AND RISKS

In southern Africa the family Amaryllidaceae has 18 genera and about 230 species, of which 210 species are endemic to the region (Snijman 2000). The plants grow in a huge range of habitats and occur in all the country's nine biomes. Since 37 of South Africa's 230 species of Amaryllidaceae qualify for the categories of threat (Critically Endangered, Endangered and Vulnerable), the number of threatened taxa has increased since the last assessments were made in 1996. Just one species, *Cyrtanthus leptosiphon* (Fig. 1), is Critically Endangered, 14 taxa qualify as Endangered, and 23 taxa are considered to be Vulnerable. Of these only 6 species—*Amaryllis paradisicola* (Fig. 2), *Apodolirion amyana*, *Clivia mirabilis*, *Gethyllis kaapensis*, *Haemanthus pumilio*, and *Hessee cinnamomea* (Fig. 3)—are preserved in national, provincial or privately owned reserves. All but 7 taxa are located in the Western and Eastern Cape Provinces.

Because of the concentration of threatened species in the Western and Eastern Cape Provinces, we are particularly concerned about the long-term survival of species here on the coastal lowlands and inland mountains, as



Fig. 3. *Hessee cinnamomea*, Cape of Good Hope Nature Reserve, Western Cape, South Africa.

well as in the Olifants River Valley, where land is increasingly being transformed. To help monitor the state of degeneration of biodiversity in these areas, the following representatives may serve as useful indicators. In the Western Cape, *Haemanthus canaliculatus* (Fig. 4) from the Betty's Bay area, and *Hessea mathewsii* (Fig. 5) and *Strumaria chaplinii* from near Saldanha Bay are highly localized in sandy coastal habitats, whereas in the Eastern Cape *Brunsvigia litoralis* and *Cyrtanthus spiralis* are known from Cape St Francis and Port Elizabeth. Each is increasingly threatened by unrelenting expansion of coastal developments (housing, recreation and transportation networks). Other species like *Haemanthus pumilio*, found on the arable clay soils of the south west Cape's coastal forelands that were previously covered by West Coast Renosterveld are now limited to the foot of Elandsberg—the last remaining preserve for this beleaguered vegetation type.

In the summer-rainfall region's uplands, the grasslands are among the most threatened ecosystems in South Africa and only 1.9% of the biome is formally conserved (Rouget et al. 2005). In particular, the temperate grasslands of the Eastern Cape, which are home to *Cyrtanthus suaveolens*, have been considerably reduced by rampant afforestation for timber. Likewise in the winter-rainfall region's arid fynbos of the Western Cape mountains and the inter-montane Olifants River Valley, the habitats of *Gethyllis undulata* and *Haemanthus nortieri* have been heavily impacted by extensively cultivated commercial crops (grapes, wheat, and potatoes) and indigenous plant products (rooibos tea).

Interestingly, the life histories of Amaryllidaceae species in southern African suggest that they have evolved to be opportunistic, a strategy that has favored their success during aridification of the region in the past. Ironically, many of these biological features—often uniquely combined in the group—also place them at risk. Apart from *Cyrtanthus* and *Pancratium*, which have conventional dry seeds, all the other South African amaryllids have specialized, large, water-rich seeds. Once released, these fleshy seeds germinate immediately, enabling them to respond quickly to favorable conditions, and their abundant reserves usually allow them to establish robust seedlings, giving them the competitive edge over other species whose seeds are slow to break dormancy and germinate. The fleshy seeds of South Africa's amaryllids have undoubtedly been a major cause in their evolutionary success (Snijman and Linder 1996). But conversely, since the seeds cannot be stored from one year to another, neither in the soil nor *ex situ* seed banks, they are likely to be the weakest link in the species' success. These short-lived seeds have only one chance to germinate and, if climatic conditions are unfavorable, they die.

Concomitant with the evolution of specialized seeds are several equally specialized modes of dispersal, which determine whether a species is widespread or highly localized. In *Brunsvigia*, for instance, the spherical shape and lightness of the dry fruiting heads enables them to tumble across the ground, dispersing seeds along the way. Many species of *Brunsvigia* are consequently widespread and none are threatened. Only one, *Brunsvigia elandsmontana* (Fig. 6), falls in the category of Critically Rare due primarily to its presence in West Coast Renosterveld, 97% of which has been transformed (Rebello 1996).

In contrast, another dispersal strategy that limits the seeds to the immediate environs of the mother plant, thereby retaining the habitats that have proved successful for survival in the past, is found in *Apodolirion*, *Clivia*, *Gethyllis*, and *Haemanthus*. Due to this fruiting habit, many species in these genera are highly localized and many are naturally rare. The fruit wall in *Clivia* and *Haemanthus*, for instance, is fleshy and sometimes brightly colored. Their round berries would appear to be attractive to birds and other small animals, but some feature, their mucilaginous tissues or toxic alkaloids, seems not to favor biotic dispersal. The same is true of the unusual elongated fruits of *Gethyllis* and *Apodolirion*.



Fig. 4. *Haemanthus canaliculatus*, Betty's Bay, Western Cape, South Africa.



Fig. 5. *Hessea mathewsii*, Saldanha Bay, Western Cape, South Africa.

Other vegetative features that influence the fate of certain species, particularly those of *Brunsvigia* and *Haemanthus*, are their large bulbs that take many years to mature. A graphic example of the difficulties this poses for species conservation is shown by *Haemanthus nortieri*, which has extremely attractive, beaver tail-shaped leaves that collect sand on their sticky surfaces (Fig. 7). A bulb grown from seed sown at Kirstenbosch National Botanical Garden took 17 years to flower for the first

time (Snijman et al. 2005). However, some bulb enthusiasts are too impatient to wait this long to obtain mature plants from seed, so many adults have been illegally removed from the wild. The bulbs, which are highly localized in seasonally moist habitats, flower sporadically in response to scattered autumn thundershowers. The rainfall, though, is often so erratic that the seedlings fail to develop. The slow rate of recruitment and man's exploitation, unfortunately, conspire to render this species extinction-prone.

In general, specialized pollinators are extremely efficient in effecting the pollination of co-evolved flowers. But where ecosystems are no longer intact, the natural processes are unlikely to persist, often endangering both animal and plant species. All the amaryllids produce nectar as a floral reward, so they have been able to adapt to specific pollinators. African sunbirds (*Nectarinia* species) are frequent visitors to the red tubular flowers of species in many plant families (Skead 1967, Manning and Paterson-Jones 2000). These include species of *Brunsvigia* and *Cyrtanthus*, most notably the endangered species *Brunsvigia litoralis*. Although mobile, the birds remain close to nesting sites. With the extensive wild fires that have swept the

Western Cape in the past five years, however, there has been a noticeable drop in the presence of birds endemic to the fynbos vegetation in certain areas (Martin and Mortimer 2004), adversely affecting the plants that depend on them for pollination.

Butterfly pollination is also remarkably well developed in southern Africa and several species of amaryllids are specifically adapted to pollination by the Table Mountain Beauty, *Aeropetes tulbaghia*. Unlike most insects, this large brown butterfly whose long, pliable proboscis enables it to sip nectar from deep-throated flowers, has an affinity for red and is attracted to the vulnerable *Cyrtanthus guthrieae* (Fig. 8) and the rare *Cyrtanthus flammulosus* (Johnson 1992, Johnson and Bond 1994). The emergence of *Aeropetes* in summer regardless of the rainfall regime has meant that it is available to pollinate only those Cape species which are able to flower during what is there the dry season. The plants that achieve this are dependent on moisture during part of the summer. But in marginal habitats affected by recurring drought, species often may not flower for many seasons.

Tangle-veined flies (family Nemestrinidae) and horse flies (family Tabanidae), with mouthparts more than 20 mm long form another unique category of pollinators that is highly developed in southern Africa. One suite of plant species adapted for pollination by these insects has flowers characterized by long, slender tubes and are pale pink to cream in color



Fig. 6. *Brunsvigia elandsmontana*, foot of Elandsberg, Western Cape, South Africa.

with dark pink to red markings (Goldblatt and Manning 2000a, 2000b). Although not yet confirmed, the flowers of *Cyrtanthus leptosiphon* (Fig. 1) are believed to be adapted to these flies, whose mouthparts are sufficiently long to reach the nectar at the base of the floral tube. Despite many hours spent observing populations of this critically endangered *Cyrtanthus* species, its pollinator has not yet been observed (John Manning pers. comm.), which possibly suggests that the fly has become locally extinct.

Species of *Strumaria*, which are self-fertile, show an even more subtle form of pollination. The aging flowers close up enabling the anthers to touch the receptive stigma. Thus in the absence of pollen from another flower, *Strumaria* species are capable of self-pollination, which in the short term ensures reproductive success. This flexibility in breeding behavior may have favored the evolution and establishment of many naturally rare species and may account for their presence in ecologically marginal areas, particularly in extremely arid southern Namibia.

Finally, the Amaryllidaceae have almost unique isoquinoline alkaloids with reputed medicinal properties that set them apart from their close relatives, the Alliaceae and Agapanthaceae. In Africa, traditional healers have exploited amaryllids for centuries in the treatment of ailments that are physiological and spiritual in origin. Harvesting of medicinal plants in South Africa is on the increase and sought-after species are becoming



Fig. 7. *Haemanthus nortieri*, Nardouwsberg, Western Cape, South Africa.

increasingly scarce. *Clivia* species are among the most commonly available taxa in medicinal plant shops in Gauteng Province, whereas in Durban, Kwazulu-Natal, market traders regard *Clivia miniata* as amongst the top 15 species most frequently demanded by consumers (Crouch 2003, Crouch *et al.* 2003). The possible reasons for this huge upsurge in harvesting from the wild are the improved infrastructure and development leading to increased accessibility and transport of medicinal plants to the markets, and loss of traditional values that formerly protected the plants because of increased financial incentive. This places huge pressure on the survival capabilities of the species and consequently exacerbates their decline.

CONSERVATION

At present, national, provincial and local authorities formally protect only 6% of South Africa's land surface (Rouget *et al.* 2005). Since so many threatened species are found on privately owned land, the South African National Biodiversity Institute launched an innovative program in 2003—The

Custodians for Rare and Endangered Wildflowers Program (CREW)—to harness the commitment and passion of individuals with a particular interest in conservation (Raimondo 2004). Its goals are to train local plant enthusiasts to survey key areas of remaining natural vegetation for the presence of threatened and endemic plants. Through appropriate networks the custodians will also be involved in the conservation of critical sites, in raising awareness of the importance of conservation and in catalyzing deals to conserve important areas of vegetation. CREW is currently active in the Western and Eastern Cape Provinces; home



Fig. 8. *Cyrtanthus guthrieae*, Bredasdorp hills, Western Cape, South Africa.

to the greatest number of threatened species of Amaryllidaceae in South Africa. Through local efforts such as these, and responsible actions by bulb enthusiasts abroad, we hope to see an improvement in the prospects for the conservation of these beautiful plants that have evolved such opportunistic but high-risk lifestyles.

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Table 1. Taxa of Amaryllidaceae whose conservation status has been assessed both within southern Africa and globally (except *Crinum acaule*). See Appendix 1 for details of the conservation categories of Hilton-Taylor (1996) and IUCN 3.1.

TAXON NAME	ENDEMISM	HILTON-TAYLOR (1996)	IUCN 3.1 OR ORANGE LIST STATUS
<i>Amaryllis paradisicola</i> Snijman	SA	NE	VU D2
<i>Apodolirion amyanum</i> D.Müll.-Doblies	SA	NI	EN B1a,b(i,ii,iii)+2a,b(i,ii,iii)
<i>Apodolirion bolusi</i> Baker	SA	R	DD
<i>Apodolirion cedarbergense</i> D.Müll. Doblies	SA	NE	Rare
<i>Apodolirion lanceolatum</i> (Thunb.) Baker	SA	R	Spars
<i>Apodolirion macowanii</i> Baker	SA	NE	VU A3c D2
<i>Brunsvigia elandsmontana</i> Snijman	SA	NE	Critically Rare
<i>Brunsvigia herrei</i> F.M.Leight. ex W.F.Barker	FSA	R	Spars
<i>Brunsvigia josephinae</i> (Redouté) Ker Gawl. [= * <i>B. gydobergensis</i> D.Müll.-Doblies & U.Müll.-Doblies]	SA	[*EX]	LC
<i>Brunsvigia litoralis</i> R.A.Dyer	SA	V	EN B1ab(iii)
<i>Brunsvigia namaquana</i> D.Müll.-Doblies & U.Müll.-Doblies	FSA	nt	LC
<i>Brunsvigia pulchra</i> (W.F.Barker) D.Müll.-Doblies & U.Müll.-Doblies	SA	R	LC
<i>Brunsvigia radula</i> (Jacq.) Aiton	SA	NI	NT
<i>Brunsvigia striata</i> (Jacq.) Aiton [= * <i>B. minor</i> Lindl.]	SA	[*nt]	LC
<i>Brunsvigia undulata</i> F.M.Leight.	SA	nt	LC
<i>Clivia caulescens</i> R.A.Dyer	FSA	nt	NT
<i>Clivia gardenii</i> Hook.	SA	nt	NT
<i>Clivia miniata</i> (Lindl.) Regel var. <i>miniata</i>	FSA	nt	Declining
<i>Clivia mirabilis</i> Rourke	SA		VU D2
<i>Clivia nobilis</i> Lindl.	SA	nt	VU B1ab(v)
<i>Crinum acaule</i> Baker	Not	nt	NT (National)
<i>Crinum campanulatum</i> Herb.	SA	R	NT
<i>Crinum lineare</i> L.f.	SA	R	VU B1ab(i,ii,iii)

Table 1. Continued.

TAXON NAME	ENDEMISM	HILTON-TAYLOR (1996)	IUCN 3.1 OR ORANGE LIST STATUS
<i>Crinum variable</i> (Jacq.) Herb.	SA	nt	LC
<i>Cyrtanthus attenuatus</i> R.A.Dyer	FSA	K	Rare
<i>Cyrtanthus bicolor</i> R.A.Dyer	FSA	R	LC
<i>Cyrtanthus brachyscyphus</i> Baker [= <i>C. rectiflorus</i> Baker]	SA	[*K]	LC
<i>Cyrtanthus brachysiphon</i> Hilliard & B.L.Burt	SA	V	EN B1ab(ii,iii,v) B2ab(ii,iii,v) C2(i) D
<i>Cyrtanthus carneus</i> Lindl.	SA	V	NT
<i>Cyrtanthus clavatus</i> (L'Hér.) R.A.Dyer	SA	R	DD
<i>Cyrtanthus debilis</i> Snijman	SA	NE	Rare
<i>Cyrtanthus epiphyticus</i> J.M.Wood	FSA	nt	LC
<i>Cyrtanthus erubescens</i> Killick	SA	R	Rare
<i>Cyrtanthus euallus</i> R.A.Dyer	SA	R	Rare
<i>Cyrtanthus falcatus</i> R.A.Dyer	SA	nt	Rare
<i>Cyrtanthus flammeus</i> Snijman & Van Jaarsv.	SA	R	Rare
<i>Cyrtanthus flavus</i> P.E.Barnes	SA	K	VU D2
<i>Cyrtanthus guthrieae</i> L.Bolus	SA	V	VU D2
<i>Cyrtanthus helictus</i> Lehm.	SA	R	LC
<i>Cyrtanthus herrei</i> (F.M.Leight.) R.A.Dyer	FSA	R	NT
<i>Cyrtanthus huttonii</i> Baker	SA	R	Rare
<i>Cyrtanthus junedii</i> P.Beauv.	SA	K	DD
<i>Cyrtanthus leptosiphon</i> Snijman	SA	NE	CR B1ab(i,ii,iii)+2ab(ii,iii,v)
<i>Cyrtanthus leucanthus</i> Schltr.	SA	R	LC
<i>Cyrtanthus loddigesianus</i> (Herb.) R.A.Dyer	SA	nt	LC
<i>Cyrtanthus macowanii</i> Baker	SA	nt	LC
<i>Cyrtanthus nutans</i> R.A.Dyer	FSA	V	Rare
<i>Cyrtanthus obliquus</i> (L.f.) Aiton	SA	NE	NT
<i>Cyrtanthus ochroleucus</i> (Herb.) Burch. ex Steud.	SA	NE	Rare

Table 1. Continued.

TAXON NAME	ENDEMISM	HILTON-TAYLOR (1996)	IUCN 3.1 OR ORANGE LIST STATUS
<i>Cyrtanthus odoratus</i> Ker Gawl.	SA	V	Rare
<i>Cyrtanthus smithiae</i> Watt ex Harv.	SA	R	Rare
<i>Cyrtanthus spiralis</i> Burch. ex Ker Gawl.	SA	V	EN B1ab(i,ii,iii)+2ab(i,ii,iii)
<i>Cyrtanthus staadensis</i> Schönland	SA	V	VU D2
<i>Cyrtanthus suaveolens</i> Schönland	SA	K	EN B1ab(i,ii,iii)
<i>Cyrtanthus thorncroftii</i> C.H.Wright	SA	R	LC
<i>Cyrtanthus wellandii</i> Snijman	SA	V	VU D2
<i>Gethyllis barkerae</i> D.Müll.-Doblies subsp. <i>barkerae</i>	SA	NE	DD
<i>Gethyllis britteniana</i> Baker subsp. <i>bruynsii</i> D.Müll.-Doblies	SA	NE	DD
<i>Gethyllis britteniana</i> Baker subsp. <i>herrei</i> (L.Bolus) D.Müll.-Doblies	SA	K	DD
<i>Gethyllis campanulata</i> L.Bolus	SA	NE	Sparse
<i>Gethyllis ciliaris</i> (Thunb.) Thunb. subsp. <i>ciliaris</i>	SA	nt	LC
<i>Gethyllis ciliaris</i> (Thunb.) Thunb. subsp. <i>longituba</i> (L.Bolus) D.Müll.-Doblies	SA	NE	NT
<i>Gethyllis fimbriatula</i> D.Müll.-Doblies	SA	NE	DD
<i>Gethyllis grandiflora</i> L.Bolus	SA	NE	NT
<i>Gethyllis hallii</i> D.Müll.-Doblies	SA	NE	Rare
<i>Gethyllis kaupensis</i> D.Müll. Doblies	SA	NE	VU D2
<i>Gethyllis lata</i> L.Bolus subsp. <i>lata</i>	SA	NE	Rare
<i>Gethyllis lata</i> L.Bolus subsp. <i>orbicularis</i> D.Müll.-Doblies	SA	NT	Rare
<i>Gethyllis latifolia</i> Masson ex Baker	SA	Ex	DD
<i>Gethyllis longistyla</i> Bolus	SA	NE	Rare
<i>Gethyllis namaquensis</i> (Schönland) Oberm.	FSA	nt	LC
<i>Gethyllis pectinata</i> D.Müll.-Doblies	SA	NE	VU D2
<i>Gethyllis roggeveldensis</i> D.Müll.-Doblies	SA	NE	Rare
<i>Gethyllis spiralis</i> (Thunb.) Thunb.	SA	nt	LC

Table 1. Continued.

TAXON NAME	ENDEMISM	HILTON-TAYLOR (1996)	IUCN 3.1 OR ORANGE LIST STATUS
<i>Gethyllis undulata</i> Herb.	SA	NE	EN B1ab(i,ii,iii)
<i>Gethyllis uteana</i> D.Müll.-Doblies	SA	NE	DD
<i>Haemanthus amarylloides</i> Jacq. subsp. <i>amarylloides</i>	SA	V	NT
<i>Haemanthus amarylloides</i> Jacq. subsp. <i>toximontanus</i> Snijman	SA	V	EN B1ab(iii,v)
<i>Haemanthus canaliculatus</i> Levyns	SA	V	EN B1ab(iii,v) C1
<i>Haemanthus dasyphyllus</i> Snijman	SA	R	Rare
<i>Haemanthus deformis</i> Hook.f.	SA	NE	NT
<i>Haemanthus graniticus</i> Snijman	SA	R	EN B1ab(i,ii,iii,v)
<i>Haemanthus lanceifolius</i> Jacq.	SA	R	NT
<i>Haemanthus namaquensis</i> R.A.Dyer	FSA	R	LC
<i>Haemanthus nortieri</i> Isaac	SA	R	EN B1ab(ii,iii,v)
<i>Haemanthus paucifolius</i> Snijman & A.E.van Wyk	FSA	K	LC
<i>Haemanthus pubescens</i> L.f. subsp. <i>arenicola</i> Snijman	FSA	R	LC
<i>Haemanthus pubescens</i> L.f. subsp. <i>leipoldii</i> Snijman	SA	R	VU D2
<i>Haemanthus pumilio</i> Jacq.	SA	E	FN C1
<i>Haemanthus tristis</i> Snijman	SA	R	Rare
<i>Hessea cinnamomea</i> (L'Hér.) T.Durand & Schinz	SA	V	VU A1ac
<i>Hessea incana</i> Snijman	SA	V	NT
<i>Hessea mathewsii</i> W.F.Barker	SA	E	EN B1ab(i,ii,iii)
<i>Hessea pilosula</i> D.Müll.-Doblies & U.Müll.-Doblies	SA	R	Rare
<i>Hessea pulcherrima</i> (D.Müll.-Doblies & U.Müll.-Doblies) Snijman	SA	R/V	Sparse
<i>Hessea pusilla</i> Snijman	SA	R	Critically Rare
<i>Hessea stenosphon</i> (Snijman) D.Müll.-Doblies & U.Müll.-Doblies	SA	R	LC

Table 1. Continued.

TAXON NAME	ENDEMISM	HILTON-TAYLOR (1996)	IUCN 3.1 OR ORANGE LIST STATUS
<i>Hesaea tenuipedicellata</i> Snijman (+ Snijman 1437)	SA	V	VU D2
<i>Hesaea undosa</i> Snijman	SA	R	VU D2
<i>Namaquanula bruce-bayeri</i> D.Müll.-Doblies & U.Müll.-Doblies	FSA	V	VU B1ab(ii,iii)
<i>Nerine bowdenii</i> Watson	SA	K	Sparse
<i>Nerine gibsonii</i> Douglas	SA	R	VU D2
<i>Nerine gracilis</i> R.A.Dyer	SA	R	NT
<i>Nerine humilis</i> (Jacq.) Herb.	SA	nt	LC
<i>Nerine huttoniae</i> Schönland	SA	K	VU A2acd D2
<i>Nerine marincowitzii</i> Snijman	SA	R	VU D2
<i>Nerine masoniorum</i> L.Bolus	SA	R	EN B1ab(i,ii,iii)
<i>Nerine pancratioides</i> Baker	SA	nt	LC
<i>Nerine platypetala</i> McNeil	SA	K	VU B1ab(i,ii,iii,iv,v)
<i>Nerine pudica</i> Hook.f.	SA	R	Rare
<i>Strumaria aestivalis</i> Snijman	SA	R	VU D2
<i>Strumaria barbarae</i> Oberm.	FSA	R	Rare
<i>Strumaria bidentata</i> Schinz	FSA	I	NT
<i>Strumaria chaplinii</i> (W.F.Barker) Snijman	SA	E	EN B1 + 2ab(i,iii)
<i>Strumaria discifera</i> Marloth ex Snijman subsp. <i>bulbifera</i>	SA	R	NT
<i>Strumaria karoocica</i> (W.F.Barker) Snijman	SA	nt	LC
<i>Strumaria karoopoortensis</i> (D.Müll.-Doblies & U.Müll.-Doblies) Snijman	SA	R	Rare
<i>Strumaria leipoldtii</i> (L.Bolus) Snijman	SA	E	VU D2
<i>Strumaria massoniella</i> (D.Müll.-Doblies & U.Müll.-Doblies) Snijman	SA	R	Rare
<i>Strumaria merxmuellariana</i> (D.Müll.-Doblies & U.Müll.-Doblies) Snijman	SA	V	Rare
<i>Strumaria perryae</i> Snijman	SA	R	Critically Rare

Table 1. Continued.

TAXON NAME	ENDEMISM	HILTON-TAYLOR (1996)	IUCN 3.1 OR ORANGE LIST STATUS
<i>Strumaria picta</i> W.F.Barker	SA	V	Rare
<i>Strumaria pubescens</i> W.F.Barker	SA	R	Rare
<i>Strumaria pygmaea</i> Snijman	SA	R	Rare
<i>Strumaria salteri</i> W.F.Barker	SA	nt	Rare
<i>Strumaria spiralis</i> L'Hér. [= * <i>Carpolyza spiralis</i> (L'Hér.) Salisb.]	SA	[*nt]	LC
<i>Strumaria unguiculata</i> (W.F.Barker) Snijman	SA	V	VU D2
<i>Strumaria villosa</i> Snijman	SA	R	Rare
<i>Strumaria watermeyeri</i> L.Bolus subsp. <i>botterkloofensis</i> (D.Müll.-Doblies & U.Müll.-Doblies) Snijman	SA	R	Rare
<i>Strumaria watermeyeri</i> L.Bolus subsp. <i>watermeyeri</i>	SA	nt	LC

* Taxa given by Hilton-Taylor (1996) which are now synonyms.

Additional abbreviations:

NE = Not Evaluated

SA = endemic to South Africa

FSA = endemic to the Flora of southern Africa region, i.e. South Africa, Lesotho, Swaziland, Namibia and Botswana

APPENDIX 1. DEFINITIONS OF THE RED DATA CATEGORIES.

<http://www.iucn.org/themes/ssc/redlists/redlistcatsenglish.pdf> provides details of the 2001 IUCN 3.1 Red List Categories:

The IUCN Red data categories used by Hilton-Taylor (1996) are as follows.

Extinct (Ex): taxa which are no longer known to exist in the wild after repeated searches of their type localities and other known likely places. This category is also used for a taxon which no longer occurs in the wild but survives in at least some form in cultivation or in a seed bank, but is probably so genetically impoverished or altered as to make it impossible to return it to a natural habitat.

Endangered (E): taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating. Included here are taxa whose numbers of individuals have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction.

Vulnerable (V): taxa believed likely to move into the Endangered category in the near future if the factors causing decline continue operating. Included here are taxa of which most or all of the populations are decreasing because of over-exploitation, extensive destruction of habitat or other environmental disturbance; taxa with populations that have been seriously depleted and whose ultimate security is not yet assured; and taxa with populations that are still abundant but are under threat from serious adverse factors throughout their range.

Rare (R): taxa with small world populations that are not at present Endangered or Vulnerable, but are at risk as some unexplored threat could easily cause critical decline. These taxa are usually localized within restricted geographical areas or habitats or are thinly scattered over a more extensive range.

Indeterminate (I): taxa known to be Extinct, Endangered, Vulnerable, or Rare but for which information is insufficient to decide which of the four categories is appropriate.

Insufficiently Known (K): taxa that are suspected but not definitely known to belong to any one of the above categories, because of lack of information.

Not threatened (nt): this is used for taxa which are no longer in one of the above categories due to an increase in population sizes or to subsequent discovery of more individuals or populations.

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TWO NEW SPECIES OF *CRINUM* (AMARYLLIDACEAE)
FROM MADAGASCAR

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PART I

In November 1996, Dave Hardy and I set out upon our second field-collecting expedition to Madagascar. Since finding African *Crinum* in bloom is dependent upon the onset of the summer rainy season, any long-range travel plans made by foreign visitors must allow for an element of flexibility. Most species have deciduous leaves; if there has been no summer rainfall, nothing will be found, whereas if there has been abundant rainfall, grasses may obscure the bulbs. So upon arriving in Antananarivo, the capital city, our first priority was to inquire into which regions had experienced decent and recent rainfall from friends, including Alfred Razafindratsira, IBS member and proprietor of Madagascan Flora. Then armed with this information, we bargained for whatever travel accommodations we could arrange, and this resulted in three separate short trips.

On one excursion, we were invited by an acquaintance on a four day sojourn through Western Madagascar, encompassing a broad zone of sparsely populated, arid landscape. The itinerary consisted of driving from Antananarivo, located in the central plateau, to Morondava on the west coast and then back in a private car. Dave's son, Zandy, accompanied us on this occasion. The one-way distance was approximately 725 km, and the plan was to drive straight through in one day. However, our contact misjudged the condition of the highway, and the journey proved to be a grueling ordeal, lasting 17 hours. The region through which we passed during the initial 475 km of the journey, from Antananarivo to Miandrivaz, was exceptionally dry, and I only observed one *Crinum* en route, a cluster of *C. ligulatum* Baker near a small stream west of Antsirabe. Then it began to rain, and it rained the remainder of the day. To make matters worse, we encountered a 125 km stretch of highway that was in dreadful condition, being just a maze of potholes. We could only drive 10–15 km/hour through this battle zone. It was 11:00 PM when we arrived in Morondava. Throughout the night, the temperature hovered at 32° C, and the humidity was 100%. My cot became a pool of perspiration.

During the following morning, Dave and I explored the region about Morondava. We encountered an interesting Baobab forest (Fig. 1), so picturesque that it would make excellent material for a postcard. We also



Fig. 1. Baobab forest near Morondava, Madagascar, November 10, 1996.

observed vanilla plants and terrestrial orchids. Later in the morning, we discovered *Crinum* growing along the banks of an irrigation ditch. Multiple bulbs were flowering, and some bore mature fruit. These bulbs bore resemblance to *C. firmifolium* Baker, but they were smaller, the leaf margins were denticulate, and the flowers were sessile; this was not *C. firmifolium*.

The next day we set out upon the return trip to Antananarivo, this time planning a leisurely pace over two days. About 90 km east of Morondava, we spied the unknown *Crinum* again, this time in cultivated rice farmland. Fortunately, we soon observed it again at 89 km south of Miandrivaz in natural habitat along the banks of a branch of the Tsiribihina River, about 100 m from the highway. Here the road was elevated above the river, and I eagerly scrambled down the embankment to the flood plain of the river and began photographing bulbs (Fig. 2) and collecting seed. When I returned to the car, it was just in time to watch Zandy capture a large chameleon. While we were engrossed in examining this novelty, a young man came running toward us from a small village nearby, yelling "Crocodile!" and pointing toward the river. Egad! About 50 m from where I had been photographing *Crinum* lay a 3 m crocodile sunning itself on a sandy shelf along the river bank. I was stunned for a few moments, and then as I attempted to return to where I had been to photograph the creature, it suddenly dashed into the river and disappeared. We spent the night in Miandrivaz, where the temper-



Fig. 2. *Crinum hardyi* Lehmiller, type locality, 89 km south of Miandrivaz, Madagascar, November 11, 1996.

ature stayed above 32° C during the night with no air movement — another sleepless night. Dave remarked that Miandrivaz was considered to be the warmest summer locality in Madagascar. The return trip to Antananarivo the next day was uneventful.

***Crinum hardyi* Lehmiller, sp. nov.**

Species *C. firmifolium* affinis, sed foliis marginatia denticulatis differt.

Type: Madagascar. 89 km south of Miandrivaz, adjacent to a tributary of the Tsiribihina River. Collected November 11, 1996, and subsequently cultivated in Southeast Texas, July 2003. **Lehmiller 1948** (Holotype: TAMU). Fig. 3.

Bulb globular, 8–10 cm in diameter, tapering to an underground neck 5–8 cm long, covered with a brown papery tunic. Leaves 10–12, forming a rosette without a false stem, suberect and arching, widest at the base and tapering to a slender point, channeled but not U-shaped, sometimes weakly undulate in older mature leaves, margins denticulate, bearing closely spaced longitudinal nerves with well-spaced cross striations visible with a magnifying glass, containing minute wooly fibers when torn apart, green, 46–112 cm long and 4.2–7.0 cm wide. Scape mildly compressed, 45–60 cm long. Spathe with 2 principal external bracts, 6.8–10 cm long, reflexed and declining or papery at anthesis, with a few internal filamentous bracts. Umbel 6–19; flowers actinomorphic, sessile, opening at night, pleasantly scented. Buds slender and pointed, white, initially closely spaced and vertical, then elongating and

inclining 30–45 degrees below the horizon but not vertically drooping, and then arising to an erect position at anthesis. Perianth tube straight at anthesis, light green, 17–20 cm long. Segments lanceolate and slender, white, unequal with the outer slightly longer and narrower, 84–90 mm long and 16–22 mm wide, small green apiculates. Filaments 6, spreading, white only at the throat, otherwise reddish purple, unequal with those attached to the inner segments longer, 54–67 mm long; mature anthers dark; pollen golden yellow. Style reddish purple, 50–95 mm long; stigma capitate. Fruit globular with a rostellum, 70–160 mm long, green turning pale greenish yellow at maturity, 30–45 mm diameter, indehiscent; seeds 1–30 per fruit, smooth, partially angulated when compressed by adjacent seeds, light green, 5–28 mm diameter.

Habitat: Western Madagascar; biphasic climate with an erratic summer rainy season and a dry winter. Riverine, growing near the banks of rivers and temporary streams.

DISCUSSION

Both *C. hardyi* and *C. firmifolium* possess the same leaf configuration. The leaves arise from the ground in corn-stalk fashion without a false stem. Leaves are widest at the base, channeled, long and slender, and taper to a

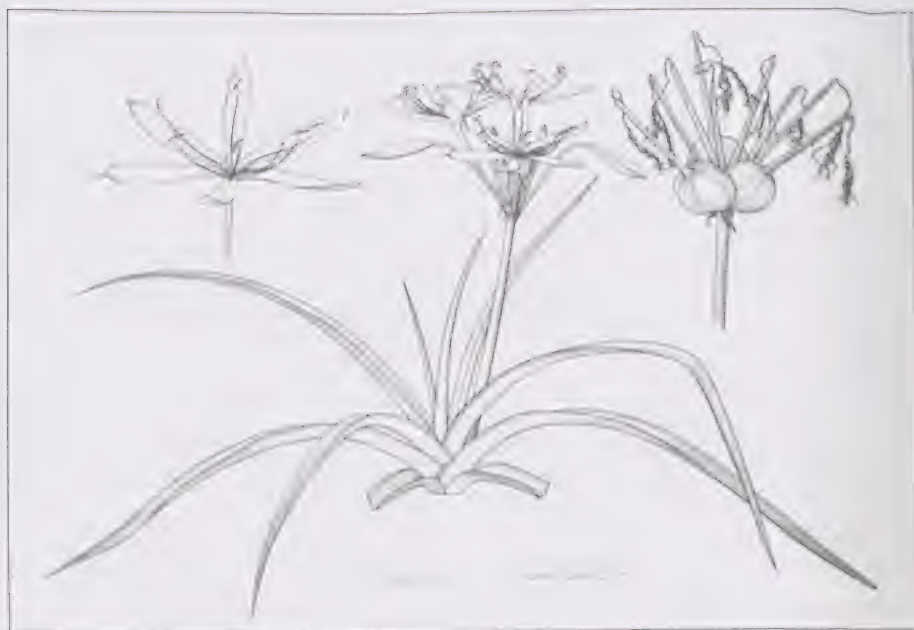


Fig. 3. *Crinum hardyi* Lehmiller; illustration including fruit. Drawing by Kristin Jakob.

slender point. In cross section, they are thicker in the mid region, but there is no offset or depressed mid rib effect. Leaves of *C. firmifolium* are much wider, up to 15 cm in width (versus 7.0 cm in *C. hardyi*), and mature leaves usually exhibit coarse undulations. However, the major foliar distinction between the species is that the margins of *C. firmifolium* are entire (smooth) whereas those of *C. hardyi* are denticulate. There are other character differences between these two species. Flowers of *C. hardyi* are sessile, whereas *C. firmifolium* possesses subsessile flowers that often have petiole-like elongations of the ovary to 10–20 mm (the latter appears more pronounced in herbarium specimens and resembles a short pedicel). Regarding budding motion prior to anthesis, buds of *C. hardyi* incline 30–45 degrees below the horizon, whereas buds of *C. firmifolium* vertically droop. Finally, tepals of *C. hardyi* at anthesis are nearly aligned in a horizontal plane (Fig. 4), while those of *C. firmifolium* are markedly recurved with tips clustered about the perianth tube (Fig. 5).

This species is named in honor of Dave Hardy, former (deceased) Senior Horticulturist at the National Botanical Institute, Pretoria, South Africa. Dave loved Madagascar and admired its peoples; he visited Madagascar more than 25 times and traveled extensively throughout the countryside.



Fig. 4. Floral form of *Crinum hardyi* Lehmiller; bulb from the type locality, cultivated in Southeast Texas.



Fig. 5. Floral form of *Crinum firmifolium* Baker; bulb collected near Fort Dauphin, Madagascar, cultivated in Southeast Texas.

PART II

The region about Ambatofinandrahana (Ato-Finandrahana) in the southern Malagasy Central Plateau is noted for its ancient outcroppings of marble called cipolins (Fig. 6). Nestled within the Itremo Mountains, this ecology is rich in succulents, many of which are restricted to this particular locality. When traveling through the countryside, one is impressed with the many stands of the giant endemic *Aloe capitata* Baker var. *cipolinicola* H. Perrier that frequently inhabit the marble formations.

In April 2003, Tom McCoy and John Lavranos set out upon a Malagasy expedition intending to photograph as many *Aloe* species as possible. Their journey included a few days of exploring the Itremo Mountains about Ambatofinandrahana, since at least 8 species of *Aloe* were chronicled from this area. During one excursion, McCoy found *Aloe calcaireophila* Reynolds in flower, and as Lavranos was not with him at the time, he returned the following morning with his companion to show him the exciting find. McCoy then climbed up and between some nearby white marble rocks (Fig. 7), and there he encountered a flat patch of fine sandy soil. Growing within the sand were clusters of a small *Crinum*. The bulbs were in leaf, the leaves being in decline and laying flat on the ground, and several bulbs bore signs of old inflorescences. Lavranos, an IBS member, considered the possibility



Fig. 6. Cipolin ecology near Ambatofinandrahana, Madagascar, January 14, 1998.

that the bulbs could be *C. razafindratsiraea* Lehmiller, but since the identity was uncertain, a few bulbs were collected (two of which were forwarded to Lehmiller for identification). Other plants growing in the immediate area besides *A. calcairophilia* included *A. capitata*, *A. cyrtopylla* Lavranos, *Euphorbia stenoclada* Baillon ssp. *ambatofinandrahana* (Leandri) Cremers, a species of *Xerophyta*, and a woody *Salvia*.

During the same encounter at Ambatofinandrahana, McCoy and Lavranos found two new species of dwarf *Aloe*. These discoveries were even more remarkable in that the two species occurred within 200 m of each other. The latter descriptions as well as a thorough detailing of the cipolin ecology were published elsewhere (Lavranos and McCoy, 2004). McCoy currently resides in Yemen, and Lavranos lives in Portugal.

***Crinum mccoyi* Lehmiller, sp. nov.**

Species interposita *Crinum filifolium* var. *brevistylum* et *Crinum modestum*.

Type: Madagascar. 2 km south of Ambatofinandrahana, in an area of white marble outcroppings, elevation 1355 m. Collected April 2003, and subsequently cultivated in Southeast Texas, May 2004. Lehmiller 1949 (Holotype, TAMU). Fig. 8.

Bulb nearly spherical, 3.5–4.5 cm in diameter, tapering to an underground neck 3.0–4.5 cm long, covered with a brown papery tunic; occurring

in clusters of 10–15 bulbs. Leaves 8–10, forming a rosette without a false stem, arching, widest at the base and tapering to a slender pointed tip, channeled but not U-shaped, non undulate, margins denticulate with occasional minute cilia noted, bearing closely spaced longitudinal nerves with well spaced cross striations visible with a magnifying glass, containing minute wooly fibers when torn apart, green, 45–53 cm long and 1.5–2.2 cm wide. Scape mildly compressed, 19–37 cm long. Spathe with 2 principal external bracts that are sometimes partially fused, 5–9 cm long, becoming papery at anthesis but still clasping about the ovary. Umbel 1–7; flowers zygomorphic, sessile, opening at night, pleasantly scented. Buds blunt, cream colored with irregular bands of pinkish red pigment more prominent distally, initially vertical, then moving outward and inclining 30–60 degrees below horizontal but not vertically drooping, then moving upward to 30–45 degrees above horizontal at anthesis. Perianth tube curved at anthesis, light green but sometimes sprinkled with small amounts of reddish pigment, 9.0–10.5 cm long. Segments lanceolate, white with irregular bands of pinkish pigment that fade post anthesis, inner and outer segments not differing significantly in length or width, 48–65 mm long and 11–16 mm wide, small green apiculates. Filaments 6, declinate, purplish red with a small white band at the throat, short and clustered about the throat, 11–16 mm long; mature



Fig. 7. Type locality of *Crinum mccoysi* Lehmiller, 2 km south of Ambatofinandrahana, Madagascar, April, 2003. Note *Aloe capitata* Baker var. *ciprolinacola* H. Perrier in the foreground. Photograph by T.A. McCoy.

anthers dark, eccentrically inserted on the stamens, 5 mm long at maturity; pollen golden yellow. Style purplish red, non emergent; stigma capitate. Ovary dark green to rust colored, 5–8 mm long and 3–5 mm wide. Fruit globular, oftentimes with a short rostellum to 10 mm long, with a distinct small pedicel < 10 mm long developing post anthesis, green, 20–30 mm diameter, indehiscent; seed few, often solitary, ovoid to obovate, smooth, light green, 10–25 mm diameter.

Habitat: South Central Madagascar; biphasic climate with an erratic summer rainy season and a dry winter. Known only from a localized sandy enclave circa 20 m x 20 m nestled within crystalline marble formations in the Itremo Mountains.

DISCUSSION

Two other Malagasy species share the unusual configuration of zygomorphic flowers born on curved perianth tubes and possessing very short declinate filaments clustered about the throat, *C. filifolium* var. *brevistylum* Perrier and *C. modestum* Baker. The former is a dwarf species with 15–25 mm diameter bulbs, 1–2 flowered umbels, and leaves 2–3 mm wide; whereas the latter is a large species with bulbs reaching 10 cm in diameter, 2–11 flowered umbels, and bluish green leaves reaching 5 cm in width.



Fig. 8. *Crinum mccoysi* Lehmillier, illustration including fruit. Drawing by Kristin Jakob.

At anthesis in *C. mccoysi* (Fig. 9), the throat is completely filled with clear semi-viscid nectar. The combination of a non emergent style, nectar-filled throat, and very short filaments clustered about the throat suggests an ideal setting for a hawkmoth pollinator. *Crinum venosum* R. Brown of Northern Australia has the same floral configuration as *C. mccoysi* and its throat also fills with clear semi-viscid nectar. However, a non emergent style is not a constant character in *C. venosum*; in some umbels, all the flowers possess non emergent styles, while in other umbels, the style may emerge a short distance to just beyond the length of the filaments in several flowers (Fig. 10). Whether or not the style of *C. mccoysi* is always non emergent requires further study; in the few fresh flowers that have been dissected, the stigma has been positioned 2–3 cm proximal to the throat. The style has been non emergent in the few flowers of *C. modestum* that I have observed. My experience has been limited to herbaria in *C. filifolium* var. *brevistylum*. Field studies are needed to determine whether or not *C. filifolium* should be separated into two different species rather than two different varieties.

Two additional *Crinum* species have been described with short filaments clustered about the throat. *Crinum brachynema* Herbert of India reportedly has zygomorphic flowers with short filaments clustered about the throat and a style shorter than the filaments; Baker (1888) remarked that it was easily distinguished by its short filaments and style. An Angolan species, *C. trifidum*



Fig. 9. Floral form of *Crinum mccoysi* Lehmiller; bulbs collected from the type locality, cultivated in Yemen. Photograph by T.A. McCoy

Nordal (1979), has short filaments clustered about the throat, but its flowers are hypocraterform and its trifid style is about 3 cm long. *Crinum mccoysi* is named in honor of Tom McCoy who discovered this species in Madagascar.

ACKNOWLEDGEMENTS

Botanical illustrator and IBS Member, Kristin Jakob of Valley Mills, California, is acknowledged for the illustrations of both species.

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Fig. 10. Floral form of *Crinum venosum* R. Brown; bulb from North Queensland, Australia, cultivated in Southeast Texas.

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A NEW NOTHOGENERIC TAXON: *XSPREKELIANTHES* (AMARYLLIDACEAE)

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When Herbert (1837) formulated his concept of Family Amaryllidaceae, he placed great significance upon defining generic characters, believing that this was the important rank in lineagics. "We should bear in mind that there can be but one real division that is identity of kind, or, in other words, generic distinction; the secret bar by which the Almighty has made His works incapable of being blended with each other, and confounded in their propagation. All divisions, except that of generic identity are artificial..." In arriving at generic distinction, Herbert conducted many hybridizing experiments. He thus combined hybridization with morphology to define 83 genera in Family Amaryllidaceae. However, Herbert professed that his knowledge was limited, and that modifications would likely occur in the future.

Indeed change came about, and when Traub (1963) presented his treatise on the Amaryllidaceae, he incorporated additional findings on chromosome number, histochemistry, embryology, and hybridizing experiments to arrive at a scheme encompassing 23 tribes and 97 genera. Interestingly though, Traub recognized 5 bigeneric hybrids. Seemingly, Herbert's concept of generic reproductive integrity was no longer valid. Additional intergeneric hybrids were soon reported post Traub.

The current state of Family Amaryllidaceae is in flux owing to molecular studies involving DNA sequences. These findings have been utilized to redefine the prevailing lineagics that evolved from Linnaeus through Herbert and Traub (Meerow and Snijman, 1998; Meerow et al., 2000). Meerow et al. (1999) summarize recent revelations regarding family Amaryllidaceae inferred from cladistic analyses of DNA sequences.

Regarding the American Amaryllidaceae, the cladistic analysis by Meerow et al. (2000) demonstrates the close genetic relationships between *Hippeastrum*, *Sprekelia*, *Zephyranthes*, and *Habranthus*. In hindsight, it comes as no surprise that bigeneric hybrids between these genera have been reported: *Hippeastrum* x *Sprekelia* = *xHippeastrelia*(?) Pradhan (1970), *Sprekelia* x *Habranthus* = *xSprekanthus* Traub (1969), and *Zephyranthes* x *Habranthus* = *xSydneya* Traub (1954), nomen illegitimum.

The purpose of this brief communication is to report the bigeneric hybrid between *Zephyranthes* and *Sprekelia*, *xSprekelianthes*.



Fig. 1. *xSprekelianthes* Lehmill, type specimen.

xSprekelianthes

Lehmill, nothogen. nov.

Bigeneric hybrid

between the genus

Zephyranthes Herbert and

the genus *Sprekelia* Heist.

Type: *Zephyranthes traubii*
(Hayward) Moldenke x

Sprekelia formosissima (L.)

Herbert, cultivated April

2003, Lehmill 1947

(holotype: TAMU). Fig. 1.

The seed parent for
this hybrid was

Zephyranthes traubii, for-

merly *Cooperia traubii*

Hayward (1936). This

bulb was collected in 1993

near Galveston, Texas,

approximately 50 km east

of Angleton, Texas, the

holotype locality for this species. *Zephyranthes traubii* is a diminutive bulb, but its flower possesses an unusually long stigma that projects well above the stamens and anthers, an ideal characteristic for hybridizing. (Fig. 2)

The pollen-parent bulb, *Sprekelia formosissima*, was originally collected in Northeast Mexico near San Luis Potosi in 1989 during a collecting expedition accompanied by T. Howard. The bulb was growing in a small crevice on a rocky ledge.

The bigeneric hybrid strongly resembles *Sprekelia*, the contribution from *Z. traubii* seeming only to effect a size reduction in the progeny bulbs (Fig. 3.). Its leaves exhibit the same arrangement as *S. formosissima*, although their dimensions are approximately 50% of those of *S. formosissima*. All progeny from this bigeneric hybrid (8 bulbs) are similar in size and floral characteristics, the only notable exception being variability in scape length. Otherwise, for someone not aware of the origin of this bigeneric hybrid, it would easily be mistaken for a small *Sprekelia*. However, it is a larger bulb than *S. howardii*, the dwarf *Sprekelia* with leaves that resemble *Zephyranthes*.



Fig. 2. *Zephyranthes traubii* (Hayward) Moldenke.



Fig. 3. Comparison of *xSprekelianthes* Lehmillier with *Sprekelia formosissima* (L.) Herbert

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All photos by the author.

ASPECTS OF THE AUTECOLOGY OF *NERINE HUTTONIAE* AND *NERINE LATICOMA*

Charles Craib

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Nerine laticoma is widespread in the more arid parts of the South African summer rainfall interior whereas *Nerine huttoniae* is confined to the Fish River basin and surrounding areas in the Eastern Cape. The two species are very similar and share in common several aspects of their autecology.

This paper concerns a discussion of the two species growing in three different soil types: sand, sandy loam and heavy clay based dolomite soils. Some amaryllids are confined to particular geology and soil types while others are found occupying several substrates ranging from sand to clay. As a general rule, but with several exceptions, the more common and widespread the plant the greater the range of soil types it tends to occupy.

Colonies of *N. laticoma* were observed for several years in the Assen area on the border between South Africa's North West and Limpopo Provinces and over a wide area in the Limpopo River basin for a distance of about 150 kilometres east of Alldays.

The Fish River and Limpopo River basins are subject to prolonged periodic droughts. In the case of both plants, flowering is poor during drought years and the bulbs may remain dormant if ground temperatures are consistently high with no moisture.

Nerine laticoma is found in sandy loams along the Limpopo river basin and is locally very common in some areas but scarce in others. Colonies of plants that grow in areas where the soil has high clay content tend to be small and sparse. Those in areas where the loam is sandy tend to be very large, consisting of thousands of plants scattered over a wide area.

The data collected over the last 20 years indicate that consistently heavy summer rains are irregular. They occur once or twice a decade and during these times *N. laticoma* flowers in profusion and sets abundant seeds. The seeding time coincides with the period when the greatest rainfall is likely, in February and March. The seeds are distributed mostly by runoff after rainfall. They lodge in slight depressions along drainage lines or around the bases of the parent plants. Germination is very rapid if the ground is moist, and the young bulbs establish themselves quickly in areas with the softest sandy soil. Seeds that fall on harder ground with a lower moisture content shrivel in large numbers in the sun.



Fig. 1. *Nerine huttoniae* growing in sandy soil along the lower Fish River in the Eastern Cape. The photograph was taken at the peak of a good flowering season in the mid-February 2004.

Plants found in the heavy loams around Alldays have a limited period in which to germinate since the soil here is often heavy loam. It dries out and cracks quickly in exposed areas but retains moisture for longer periods under baobab trees (*Adansonia digitata*) and around and under *Acacia* scrub. The requirements for successful germination are periods of consistent moisture in February and March. Conditions for germination are most readily met in areas of sandy loam accounting for the fact that the plants are commonest in these regions.

The Assen and Northam areas, along the border between the North West and Limpopo Provinces, are hilly and mountainous with flat plains. The plains contain numerous open areas around sheets of flat exposed dolomite. The soil here is too shallow for the establishment of trees and shrubs but affords colonies of *N. laticoma* a suitable niche. The hilly areas may also be densely colonised by *N. laticoma*. There are some large colonies east of Northam where they grow on stony west-facing mountain slopes.

The soil is a heavy dolomite derived loam rich in clay. The topography of hills and plains makes for different moisture regimes and germination conditions for *N. laticoma*. The carrying capacity of this habitat is greater in relative terms than that in the Limpopo River basin since there is little or no relief in this extensive river basin.

The Assen region, like the Limpopo River basin, tends to be rather arid with summers of prolonged consistent rain only occurring once or twice a decade. The *N. laticoma* flower mostly in late January and February. A few thundershowers are sufficient to funnel water off the exposed sheets of rock onto the surrounding soil. As a result of this the nerines come into leaf and a few bulbs flower nearly every summer even in dry years. Mass flowering only occurs in consistently moist periods in the later summer months.

The soil around the rock sheets dries out very quickly, within a matter of a few days, after rain. A great deal of seed is lost each season drying out in the sun. The populations of bulbs remain stable with a slow recruitment of new individuals to the population.

The plants growing on mountain slopes are much larger. The soil is the same heavy loam but retains moisture for much longer after rain. There is also a covering of short grass at the flowering and seeding time and the slopes are lightly wooded. These moisture retentive areas are conducive to the germination of large amounts of seed in years of high rainfall.

Nerine huttoniae favors open areas of ancient alluvial sand along the lower Fish River in the Eastern Cape. The plants are locally numerous in some habitats. The Fish River basin is often very dry for years on end, but a few showers are enough to penetrate the soil and bring *N. huttoniae* into flower.

The peak flowering season for *N. huttoniae* is February. February 2004 was an ideal year to observe the flowering and seeding process along the lower Fish River. Most of the mature bulbs flowered, which resulted in a good seed set.

The area is densely settled with rural villages. Domestic stock, mostly sheep and goats, graze in the surrounding countryside. The nerines are absent, in as far as could be ascertained, from numerous areas with heavy clay soil. This habitat is probably marginal for the nerines and, coupled with heavy grazing pressures in the surrounding veld, the bulbs are unlikely to survive here in the long term.



Fig. 2. Details of an umbel of *Nerine huttoniae* flowers.



Fig. 3. White flowered *Nerine laticoma* photographed in February in a year of exceptional rainfall in the western Limpopo River basin, Limpopo Province.



Fig. 4. Details of an umbel of *Nerine laticoma* flowers. The plant was photographed west of Beauty in the western Limpopo River basin, Limpopo Province.

The nerine populations growing in sand are healthy with numbers of young and seedling plants observed, indicating consistent regeneration. The nerines are not grazed. Animals moving across the habitat loosen soil around the plants creating ideal conditions for the seeds to germinate.

Much of the lower Fish River area now consists of game farms. It would be useful to monitor populations of *N. huttoniae* here to see what impact the change of land usage has on the plants.

Grazing plays an important double role in the recruitment of new individuals to *N. huttoniae* and *N. laticoma* populations. Some seeds are trampled and the animals play a part in regulating the number of seeds available for germination. Grazing is beneficial where the plants grow in sandy areas. However, in areas where soil consists of heavy clay on flat ground, too much seed may get destroyed in some seasons. Grazing pressures are seldom exactly the same from one season to the next. Trampling generally occurs when animals move across the nerine habitat to browse on nearby shrubs. Prolonged droughts kill off numbers of nerine seedlings ensuring in the end that few new bulbs reach flowering size.

Photo credits: 1–2, Connall Oosterbroek; 3–4, Laurian Brown.

***NERINE PANCRACTIOIDES* IN THE GRASSLANDS OF SOUTH AFRICA'S KWAZULU NATAL PROVINCE**

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Nerine pancratioides is associated with hilly grassland. In its natural state the grassland contained few trees and shrubs. It is dissected by perennial and seasonal streams, as well as temporarily inundated marshes and depressions. Fires and grazing were responsible for keeping the grassland free from accumulations of dead grass and for redistributing nutrients in the environment prior to the advent of permanent human settlement.

Exotic afforestation and invasion by exotic weeds has been responsible for widespread transformation of the grassland habitat. The purpose of this paper is to examine the transformations that have taken place and their consequences for populations of *N. pancratioides* in the various grassland niches which the bulbs occupy.

The modern tendency is towards the preservation of ecosystems rather than only a focus on species within them. However, prior to the preservation of any ecosystem, it is necessary to identify and examine the causal chains that govern the growth of plants in particular ecosystems. The ecology of grasslands is integrally linked to cycles of fire, rainfall and drought. These cycles determine a number of other factors such as the absence or abundance of pollinators based on the flowering performance of different plants in given seasons.

The study area comprised the headwaters of a river, and its associated hills, marshland and streams in the foothills of the southern Drakensberg. This area encompasses most habitat types to which *N. pancratioides* has adapted.

Streams that meander through rocky grassland, with their associated temporarily inundated marshes and moist stream banks, are the most densely utilized *N. pancratioides* habitat. The plants occupy, but on a much reduced scale, some of the shallow depressions in open grassland which fill up temporarily with water after rainfall. Moist grassy hillsides, usually around seepage areas, are also favored. The mass flowering of plants in these habitats are limited to years of good rainfall in late summer and early autumn January to early April. These habitats, in which distinct processes can be observed in the growth cycle of the plants, once intergraded in times

past. They represented the expression of the totality of habitat to which *N. pancratioides* has become adapted.

In recent decades the hydrology of the area has been changed by the spread of exotic invasive plants, roads that have truncated the habitats and grazing livestock, all of which have had an impact on the regeneration of the plants. Alteration in the burning regime of the grassland has played another significant role in the population dynamics of the bulbs. Most modern changes to the environment and associated processes in the life cycle of the nerines, have been brought about by human land use patterns. These are discussed in more detail below.

Nerine pancratioides populations associated with streams grow on their moist banks and the associated grassy depressions which fill up with water after flooding and rainfall. A good deal of the habitat associated with streams is rocky and unsuited to the nerine. Flooding and inundation of the habitat begins in December, and continues through January, usually peaking

in late January and early February when the greatest period of consistent prolonged rainfall can be expected. The bulbs generally come into flower in February with the peak flowering period from mid-February to mid-March. The plants seed at different times with the overall seeding period lasting some 5–6 weeks. This allows the plants to take advantage of fluctuating water levels to disperse their seeds. Some flooding is severe and many seeds are washed far into the surrounding grasslands. In other instances with only minor rises in water levels, the seeds are distributed around the parent plants.



Fig. 1. *Nerine pancratioides* in a temporarily inundated marsh in the foothills of the southern Kwazulu Natal Drakensberg. The photograph was taken towards the end of March 2004, late in the *N. pancratioides* flowering season.



Fig. 2. Details of an umbel of *Nerine pancratioides* flowers.

Some of these low lying areas have ideal grazing conditions for domestic stock and the nerines are heavily trampled at flowering time. Some farmers do not fence the grassland right down to the stream banks as fences get damaged by flood waters. These areas are protected from grazing, and colonies of the nerines may become extensive. In most instances only a fraction of the associated habitat can be used by the nerines owing to grazing pressures.

Temporarily inundated depressions, away from streams, quite often have populations of *N. pancratioides*. Moist depressions in road reserves are inaccessible to domestic stock. The farmland is fenced off well before the road leaving several meters where no grazing occurs. As grazing plays little or no role in the flowering and seeding of the plants, groups of bulbs may become quite large. The seeds are distributed by fluctuations in water levels or else, during dry periods, fall around the parent plants. Bulbs frequenting depressions in open farmland only obtain the chance to flower and seed during years when these sites are not heavily grazed.

Hillside population of *N. pancratioides* are often the last groups of plants to come into flower. This is usually in the second half of March if there has



Fig. 3. Large bulbs of *Nerine pancratioides* in a habitat extensively invaded by the American bramble. The few remaining grassy patches amongst the brambles will die off as they no longer form part of a fire ecology necessary for continuity of grassland.

been regular rainfall in the preceding months. It is likely that, during years of below average rainfall, these plants remain dormant.

The flat, low lying areas around streams are preferred by grazing animals. Grass in the hilly areas is rapidly grazed and the animals frequent the pastures in the lowlands. Grazing on the hillsides is significant in that it keeps the grassland short and open, which are the conditions required for optimum flowering.

Grazing pressures vary with land use patterns. It has already been pointed out that some bulbous plants have become adapted to rudimentary pastoralism (Craib, 2004). The settlement patterns of local people in the study area take the form

of large villages with grazing areas close by. The grazing lands consist of steep hillsides and flat more open grassland. *N. pancratioides* is well represented on some of the moist hillsides and appears to have benefited from grazing. The grassland is cropped short which benefits the growing and flowering requirements of the nerine. There is some habitat degradation but erosion is kept in check by the rocky composition of the hillsides. There is, notably, little invasion of alien plants at present, nor forestation in the area.

Grazing pressures may be severe on some conventional farmland. This is so as much farmland has been given over to timber forests. Livestock is therefore limited to certain areas for grazing and these quite often coincide with *N. pancratioides* habitat. In order to conserve the bulbs in the long term it will be necessary for farmers to actively manage the grazing of their stock in these restricted areas.

The effects of forestation are twofold. They have destroyed some *N. paniculata* habitat in instances where forests traverse moist hillsides. In other cases dense forestation interrupts natural processes. There is some preliminary evidence to indicate that streams in heavily forested parts flood less frequently than in unforested areas, but that floods are much more severe when they occur. This is a complex subject but would require more detailed study if ecosystems in the area are to be conserved.

The most serious problem at present is habitat degradation and destruction through invasive exotic vegetation. The American bramble, *Rubus cuneifolius*, has seriously invaded a large wetland and is in the process of smothering an extensive colony of *N. paniculata*. The process is nearing the end now with only the very large bulbs that are able to grow and flower amongst the brambles surviving. The brambles are in the process of expanding into the adjacent hillsides. Once the adult bulbs die off, there will not be another generation of plants to replace them resulting in several local extirpations in this area.

Kikuyu grass, *Pennisetum clandestinum*, has already destroyed grassland habitat mostly in the KwaZulu Natal midlands. It has started to invade parts of the grassland in the study and may become a serious problem in some parts.

It is evident that most of the study area consists of either destroyed grassland, which has made way for exotic timber, or else disturbed grassland, where processes in the ecosystem have been altered. Some of these processes are more easily managed than others. Resources for conserving ecosystems are usually scarce. In the case of this *Nerine*



Fig. 4. Grassland invaded by exotic weeds. Weeds invade grassy patches, as they die off, amongst heavy bramble infestations. The weeds temporarily colonize the open patches before they are usurped by the brambles

species, the most cost effective method is likely to consist of farmer awareness programs. It may be worth conserving the plants in all their present habitats by enlisting the services of landowners. Certain areas could later be identified for more concerted preservation efforts by enlisting a range of skills for this purpose.

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All photographs by Carol Knoll

STRUMARIA HARDYANA IN ITS HABITAT ON THE FRINGES OF THE NAMIB DESERT IN SOUTH WESTERN NAMIBIA

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Strumaria hardyana has a limited distribution range in the south western corner of Namibia. This is an arid area with two seasons in which rain may fall, late summer and early autumn through the winter. Several years may pass in succession without any autumn or winter rain. The autumn rain falls in the form of thundershowers whereas the winter rain is the result of powerfully developed extensive cold fronts which sometimes bring rainfall to the southern Namib Desert and the pro-Namib, the region to the east of the main desert.

Strumaria hardyana occupies two distinct habitats. The plants grow in gently undulating hilly areas around the mountain foothills north of Rosh Pinah. They are also found growing in isolated colonies with large numbers of bulbs adjacent to black limestone cliffs and sheets of exposed limestone in the Witputs area. Witputs is in the north of the rather small distribution range which is only about 50 km long.

The plants come into leaf and flower very irregularly and may remain dormant for several successive years. The 2003/2004 growing and flowering season provided an opportunity to collect interesting research data on the growth and flowering habits of the plants. The region had no winter rain until early August 2003. At this time a lot of rain fell in patches over a 48 hour period. The habitat around Witputs was saturated and the strumarias sprouted a mere 2 days after the rains had fallen. The leaves were fully developed about five days later despite very cold temperatures. Seedlings were equally quick to sprout and the grass-like appearance of the leaves readily distinguished them from the adult plants.

Many rocky niches were filled to capacity with adult and young bulbs. In several cases the uniform sizes of the leaves on groups of young plants could be taken to indicate that the seeds which produced them had germinated at the same time.

The hilly habitat south of Witputs lacks extensive rock outcrops. The rock sheets and cliffs around Witputs funnel water off onto the surrounding habitat completely saturating it after rain. In the Spitskop area to the south the August rains had moistened the soil, but there was not enough moisture to bring the bulbs into leaf.

A good rainstorm occurred in the early autumn of 2004 saturating the habitat around Witputs. The *S. hardyana* came into flower in large numbers and were in seed in mid-May. A few of the bulbs were still in the early stages of flowering.

Seeds that had fallen from the adult plants had either rolled into sandy crevices between rocks or were lying on the open ground. At least half the seeds had fallen onto sheets of rock at the time observations were made at one colony.

The seeds roll off gently sloping rocks, quite often landing in soil pockets. Seeds that land up on rock sheets, however, require runoff after rainfall to spread them to areas where they can germinate. Successive rain showers in the autumn months are quite rare and conditions conducive to mass germination of seeds throughout the habitat must be an occasional event.

The Spitskop area to the south had much less rain. It was sufficient to bring succulents such as *Tylecodon reticulatus* subspecies *phyllopodium* into leaf, but not to stimulate the strumarias to flower.

S. hardyana seeds have enough reserves to produce a root to penetrate the soil and a set of leaves in the absence of rainfall. Rainstorms, such as the one which occurred around Witputs in the autumn of 2004, loosen the soil. The runoff also forms swathes of sand adjacent to the rock sheets where the



Fig. 1. *Strumaria hardyana* usually comes into leaf after autumn showers, often at the same time as the bulbs flower. Some bulbs also flower in the leafless state.



Fig. 2. The white flowers of *Strumaria hardyana* are very similar to those of *Strumaria truncata*, a species that occurs hundreds of kilometres to the south in South Africa.

bulbs grow. These conditions permit the development of some young bulbs even if there are no further rainstorms in the autumn.

During the late autumn and winter months most of the *S. hardyana* habitat, which is south-facing, is in shade for most of the day. Only one winter shower is required to keep the habitat moist for long periods.

All photographs by Connall Oosterbroek.

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A NEW *HYMENOCALLIS* FROM THE STATE OF GUERRERO, MEXICO

T. M. Howard

1580 Graytown Rd., St. Hedwig, TX 78152

Hymenocallis lehmilleri T. M. Howard, sp. nov.

H. maximilliani, *H. baumlii*, et *H. astrostephana* affinis en planta parvus, foliis expansus minus destitus extra costalis, florens parvus et viridi-albus differt. Crescens en habitatio litorallis.

Bulb solitary, or one of a cluster, ca. 4 cm long, ca. 4 cm high, with blackish-brown tunics. Leaves 6–8, 38–41 cm long, 3–4 cm wide, widest at the middle, dark glossy green, spreading. Scape ancipitous, dull green, 30–38 cm long, 15 mm wide at base. Spathe bracts 3.5–4 cm long, 1.3 cm wide. Flowers 4–6, lightly fragrant, opening 1–2 at a time. Tepal tube straight, 9–10 cm long, whitish in upper 1/3; segments recurved, not adnate to cup, 7 cm long, 0.5 mm wide, greenish-white. Staminal cup 7 cm long, 1–1.5 cm wide, dilating from a short tubulose base, funnelform, becoming subrotate apically,

with minute denticulations between the filaments.

Filaments 3 cm long, white at base, green above. Anthers ca. 1.5 cm long, versatile; pollen orange-yellow. Style flexuose, green; stigma capitate. Ovary sessile; ovules 7–8 per locule. Seeds dull green, angled, 1.5 cm long, polyembryonic.

TYPE: T. Howard 94–12. Mexico, coastal Guerrero, in swales on coastal side of Highway 200, between Acapulco and Atoyac in early July (holotype: TAMU).

This plant was found up the coast from Acapulco between Acapulco and Atoyac, Guerrero, growing near the coast in swampy



Fig. 1. *Hymenocallis lehmilleri*.



Fig. 2. *Hymenocallis lehmilleri*.



Fig. 3. *Hymenocallis lehmilleri*



Fig. 4. *Hymenocallis astrostephana*

places. It is slightly smaller than other *Hymenocallis* from that general area (Table 1), with narrow spreading foliage lacking costate ribs, and having somewhat smaller greenish white flowers. I am pleased to name it for Dr. David Lehmiller, an amaryllid fancier interested in *Hymenocallis* and *Crinum*, who was present at the time of the collection.

All photographs by David J. Lehmiller.

Table I. Comparison of *Hymenocallis lehmilleri* and *H. astrostephana*.

Character	<i>H. astrostephana</i>	<i>H. lehmilleri</i>
Leaves	Usually ribbed between margins and midrib.	Not ribbed.
Flower color	White.	Greenish-white.
Tube	11–14 cm long.	9–10 cm long.
Staminal cup	1.3–2 cm wide with 0.5 cm denticulations; forms six-pointed star between filaments.	1–1.5 cm wide; denticulations minute and indistinct.
Anthers	2 cm long.	1.5 cm long.
Ovule number	3 per locule.	7–8 per locule.
Habitat	Ca. 1524 m elevation, in pastures and fields.	Sea level at margins of ponds.

VASE LIFE OF TUBEROSE (*POLIANTHES TUBEROSA* L.) 'SHRINGAR' AND 'MEXICAN SINGLE' SPIKES AS AFFECTED BY PULSING FOLLOWED BY DURATION OF DRY COOL STORAGE

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ABSTRACT

A study was undertaken to determine the effect of a pulse treatment (sucrose 10 per cent + $\text{Al}_2(\text{SO}_4)_3$ 250 ppm) followed by dry cool storage (4–5°C) for 3, 4, 5 and 6 days on spikes of tuberose cvs Shringar and Mexican Single. In cv. Shringar, various parameters, i.e., rachis length; wilt-ing of the first, third and last opened floret pair; number of fully opened florets; length of third opened floret pair (first, in 'Mexican Single'); diameter and length of last opened floret pair (diameter of third in 'Mexican Single'); fragrance; water uptake; useful life and vase life varied significantly from the control. Significant increase in vase life accompanied up to 4 ('Shringar') or 5 ('Mexican Single') days cool, dry storage. 'Shringar' had maximum vase life (6.75 days) after 3 days dry cool storage. We concluded that both cvs. can be stored dry and cool for 4 and 5 days respectively after pulsing with 10 per cent sucrose + 250 ppm $\text{Al}_2(\text{SO}_4)_3$.

INTRODUCTION

Tuberose (*Polianthes tuberosa* L.) is one of the most important bulbous ornamentals of tropical and subtropical areas. Its long spikes are excellent for table decoration. The flowers are highly perishable, and need to be treated with suitable chemicals to enhance their vase life and improve quality. It has been reported that pulsing treatment prevent vascular infections and inhibits ethylene production, which results in prolonged storage period and higher quality flowers with increased vase life (Paulin, 1996; Sankar Vidhya and Bhattacharjee, 2002). Experiments on increasing vase life and quality of tuberose cut spikes have been conducted with varying success (Reddy et al., 1995). There is little information regarding influence of chemicals and low temperature storage on tuberose cut spikes. Consequently, an investigation was undertaken to study the combined influence of chemicals and dry cool storage on vase life and quality of tuberose spikes.

MATERIALS AND METHODS

The present investigation was carried out during July–September 2001 by procuring tuberose spikes from the research plot of the All India Coordinated Research Project on Floriculture, Indian Agricultural Research Institute, New Delhi-110012. The cut spikes were harvested in the morning between 7 AM and 8 AM at a stage when the lowermost two basal florets were fully opened. These were transferred immediately to a bucket containing fresh tap water and taken to the laboratory. The cut spikes were cut to a length of 60 cm. After the pulsing treatment with 10% sucrose + 250 ppm $\text{Al}_2(\text{SO}_4)_3$ for 12 hours, the cut spikes were packed in 70 cm x 40 cm polyethylene bags of 80-gauge thickness. The open end of each bag was folded twice and then stapled. The bags were punched uniformly for ventilation. After pulsing, the cut spikes were kept at low temperature storage (4–5° C) for 3, 4, 5 and 6 days, respectively. After storage, the cut spikes were taken out and kept in uniform sized bottles (500 ml capacity) containing 300 ml tap water. One set of cut spikes was kept in tap water which served as control. The experiment consisted of five treatments replicated four times in a completely randomized design, with five cut spikes per replication. Vase life evaluation of the cut spikes was carried out in the laboratory under ambient temperature (25 °C). The useful life was defined as the period for which most basal florets remain fresh. Cut spikes were observed every day for senescence, and the total period of vase life was noted in days. The end of useful vase life was marked either by wilting of florets, browning or dropping of florets, and dessication of outer petals. Vase life was defined as the total number of days until half of the florets on a spike wilted.

RESULTS

EFFECT OF PULSING WITH SUCROSE 10% SUCROSE + 250 PPM $\text{Al}_2(\text{SO}_4)_3$, FOLLOWED BY DRY COOL STORAGE (4–5°C) ON FLORET OPENING AND VASE LIFE OF TUBEROSE CV. SHRINGAR

It is evident from Table 1 that pulsing cut spikes of tuberose with 10% sucrose + 250 ppm $\text{Al}_2(\text{SO}_4)_3$ for 12 hours significantly increased rachis length, retention of fragrance, water uptake, and delayed wilting of first, third and last opened floret pairs, thereby extending useful life and vase life. Maximum increase in rachis length (4.60 cm) was recorded after 3 days storage vs. the control (3.13 cm). The increase in rachis length decreased

with increase in storage days (3–6 days). Maximum floret life of first, third and last opened pair (2.90 days, 3.70 days and 4.20 days, respectively) was observed after 3 days storage vs. the control (2.00 days, 3.10 days, and 3.14 days, respectively). Maximum retention of fragrance (3.30 days) occurred after 3 days of storage (control: 2.20 days). Maximum water uptake (39.50 ml) was recorded after 3 days of storage (control: 32.10 ml). Spikes stored for 3 days has a maximum useful life of 2.70 days vs. 1.9 days for the control, and a maximum vase life of 6.75 days (control: 5.50 days). After pulsing with sucrose (10 per cent) + $\text{Al}_2(\text{SO}_4)_3$ (250 ppm) for 12 hours cut spikes can be stored dry and cool for 4 days without affecting the vase life.

EFFECT OF PULSING WITH SUCROSE (10 PER CENT) + $\text{Al}_2(\text{SO}_4)_3$ (250 PPM) FOLLOWED BY DURATION OF DRY COOL STORAGE (4–5°C) ON FLORET OPENING AND QUALITY OF TUBEROSE SPIKES CV. SHRINGAR

Pulsing of tuberose cut spikes with sucrose (10 per cent) + $\text{Al}_2(\text{SO}_4)_3$ (250 ppm) for 12 hours had significant effects in opening of florets, length of third floret pair and diameter and length of last opened floret pair (Table 2). Maximum number of fully opened florets (22.60) was recorded after 3 days of storage vs. 12.6 in the control. The second treatment was 4 days of storage for cut spikes. Maximum increase in length of the third floret pair and diameter and length of last opened floret pair (5.36 cm, 3.77 cm and 5.31 cm, respectively) was recorded after 3 days of storage. Number of half opened and unopened florets, diameter and length of first floret pair, and diameter of third floret pair did not vary significantly over the control. Number of fully opened florets on the spikes can be increased after pulsing with the aforementioned solution.

EFFECT OF PULSING WITH SUCROSE (10 PER CENT) + $\text{Al}_2(\text{SO}_4)_3$ (250 PPM) FOLLOWED BY DURATION OF DRY COOL STORAGE (4–5°C) ON FLORET QUALITY AND VASE LIFE OF TUBEROSE SPIKES CV. MEXICAN SINGLE

Pulsing of tuberose spikes with sucrose (10 per cent) + $\text{Al}_2(\text{SO}_4)_3$ (250 ppm) for 12 hours had significant effects on increase in rachis length, floret life of first, third and last opened pair, water uptake, retention of fragrance and extension of useful life and vase life (Table 3). Maximum increase in rachis length (5.20 cm) was recorded after 3 days of storage (control, 3.40 cm). The second best treatment was 4 days of storage where a 4.90 cm increase in rachis length was recorded over the control. Maximum delay in wilting of the first, third and last opened floret pair was recorded after 3

days of storage (2.8 days, 3.5 days, 4.0 days, respectively) vs. the control (2.1 days, 2.4 days and 3.1 days, respectively). Cut spikes stored for 3 days retained fragrance for 3.5 days (control, 2.0 days). Maximum water uptake (35.2 ml) was recorded after 3 days of storage (control, 25.1 ml). Maximum useful life (2.5 days) was recorded after 3 days of storage (control, 1.5 days). Maximum vase life (6.0 days) was also observed after 3 days of storage (control, 4.25 days). Vase life of cut spikes decreased with an increase in storage days. Cut spikes of tuberose can be dry cool stored for 5 days after pulsing without affecting vase life and quality.

EFFECT OF PULSING WITH SUCROSE (10 PER CENT) + $\text{Al}_2(\text{SO}_4)_3$ (250 PPM) FOLLOWED BY DURATION OF DRY COOL STORAGE (4–5 °C) ON FLORET OPENING AND QUALITY OF TUBEROSE SPIKES CV. MEXICAN SINGLE

Pulsing tuberose spikes with sucrose (10 per cent) + $\text{Al}_2(\text{SO}_4)_3$ (250 ppm) had significant effects on floret opening, length of first floret pair, diameter of third floret pair and length of last opened floret pair (Table 4). Maximum number of fully opened florets (23.5) was recorded after 3 days of storage (control, 11.0). The second best treatment was 4 days of storage. Length of first floret pair, diameter of third floret pair and length of last opened floret pair varied significantly over the control. Diameter of first floret pair, length of third floret pair and diameter of last opened floret pair did not vary significantly. Floret opening was enhanced after pulsing the cut spikes with sucrose (10 per cent) + $\text{Al}_2(\text{SO}_4)_3$ (250 ppm) for 12 hours regardless of storage duration.

DISCUSSION

Influence of sucrose and $\text{Al}_2(\text{SO}_4)_3$ in promoting vase life and improving the quality of flowers has been reported in rose (Halevy et al., 1978), in gladiolus (Mayak et al., 1973; Rameshwar, 1974) and in tuberose 'Mexican Single' (Mukhopadhyay, 1980). $\text{Al}_2(\text{SO}_4)_3$ is known to influence the vase life of cut flowers by acidifying the vase solution (Halevy and Mayak, 1981), keeping it free of microorganisms, and helping to prevent the plugging of conducting tissues (Deswal and Patil, 1983), resulting in greater solution uptake (Gowda, 1990). Mukhopadhyay (1980) attributed the improvement in the floral development and keeping quality of cut spikes in tuberose to antimicrobial properties of $\text{Al}_2(\text{SO}_4)_3$. Sucrose reduces the moisture loss in cut flowers by decreasing the aperture size of the stomata (Aarts, 1957; Marousky, 1971), which results in improved water balance in the spike tis-

sue. It may also prevent increase in endogenous levels of ABA and therefore delayed senescence (Bhaskar et al., 2000).

The cut spikes of tuberose cultivars 'Mexican Single' and 'Shringar' can be dry cool stored at 4–5° C for a maximum period of 4–5 days without affecting their ultimate vase life and quality. Difference in flower longevity and quality among the varieties may be due to differences in anatomical, physiological, physical, biochemical and genetic characteristics. Different cultivars vary in stem diameter and rigidity, which ultimately affects postharvest life (Nowak and Rudinicki, 1990). Variation in vase life among the different cultivars has been attributed to differences in number of thick walled supporting cells in the xylem element and phloem fibers, and presence or absence of a complete ring of secondary thickening in the flower peduncles (Zamski et al., 1991). Stomatal activity can affect flower vase life as well (Mayak et al., 1974). Variation in water uptake among different cultivars may be due to differences in diffusive resistance of leaves in the field (Jodo et al., 1989) or degree of bacterial or fungal contamination of vase water (De Stigter and Broekhuysen, 1986).

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Table 1. Influence of pulsing with sucrose (10 per cent) + $\text{Al}_2(\text{SO}_4)_3$ (250 ppm) followed by duration of dry cool storage (4–5°C) on floret quality and vase life of tuberose spikes cv. Shringar

Storage days	Increase in rachis length (cm)	Number of florets per spike	1st floret pair wilting (days)	3rd floret pair wilting (days)	Useful life (days)	Last opened floret pair wilting (days)	Fragrance (days)	Water uptake (ml)	Vase life (days)
3	4.60	40.30	2.90	3.70	2.70	4.20	3.30	39.50	6.75
4	4.40	37.80	2.80	3.50	2.60	3.90	3.00	37.20	6.00
5	4.30	39.40	2.50	3.30	2.40	3.50	2.80	34.20	5.75
6	3.80	40.10	2.10	3.00	2.00	3.00	2.30	30.40	5.25
Control ^a	3.13	39.70	2.00	3.10	1.90	3.14	2.20	32.10	5.50
SEm \pm	0.10	0.99	0.06	0.08	0.07	0.09	0.06	0.96	0.14
F test	**	NS	**	**	**	**	**	**	**
CD at 5%	0.32	3.13	0.20	0.26	0.22	0.31	0.21	3.03	0.46

^a Cut spikes neither pulsed nor stored

** Highly significant, NS - Non significant

Table 2. Influence of pulsing with sucrose (10 per cent) + $\text{Al}_2(\text{SO}_4)_3$ (250 ppm) followed by duration of dry cool storage (4–5°C) on floret opening and quality of tuberose spikes cv. Shringar

Storage days				1st floret pair		3rd floret pair		last opened floret pair	
	No. of florets fully opened	No. of florets half opened	No. of pair unopened	Diameter (cm)	Length (cm)	Diameter (cm)	Length (cm)	Diameter (cm)	Length (cm)
3	22.60	5.60	12.10	3.91	5.43	3.85	5.36	3.77	5.31
4	17.50	7.20	13.10	3.83	5.41	3.77	5.17	3.71	5.16
5	15.50	9.30	14.60	3.79	5.40	3.67	4.99	3.65	4.95
6	14.80	10.20	15.10	3.71	5.35	3.61	4.92	3.58	4.85
Control ^a	12.60	11.20	15.90	3.61	5.25	3.52	4.83	3.43	4.72
SEm ±	0.43	0.30	0.39	0.10	0.16	0.10	0.14	0.07	0.15
F test	**	NS	NS	NS	NS	NS	*	*	*
CD at 5%	1.35	0.95	1.24	0.33	0.52	0.33	0.46	0.24	0.49

^a Cut spikes neither pulsed nor stored

* Significant at 5%, ** Highly significant, NS - Non significant

Table 3. Influence of pulsing with sucrose (10 per cent) + $\text{Al}_2(\text{SO}_4)_3$ (250 ppm) followed by duration of dry cool storage (4–5°C) on floret quality and vase life of tuberose spikes cv. Mexican Single.

Storage days	Increase in rachis length (cm)	Number of florets per spike	1st floret pair wilting (days)	3rd floret pair wilting (days)	Useful life (days)	Last opened floret pair wilting (days)	Fragrance (days)	Water uptake (ml)	Vase life (days)
3	5.20	42.50	2.80	3.50	2.50	4.00	3.50	35.20	6.00
4	4.90	40.20	2.70	3.30	2.30	3.70	3.30	32.90	5.50
5	4.60	41.70	2.50	3.10	2.00	3.50	3.10	29.30	5.25
6	4.10	40.50	2.20	2.80	1.90	3.20	2.80	26.70	4.50
Control ^a	3.40	47.30	2.10	2.40	1.50	3.10	2.00	25.10	4.25
SEm ±	0.11	1.41	0.06	0.10	0.05	0.07	0.09	0.68	0.12
F test	**	NS	**	**	**	**	**	**	**
CD at 5%	0.36	4.45	0.21	0.32	0.17	0.22	0.29	2.16	0.40

^a Cut spikes neither pulsed nor stored

** Highly significant, NS - Non significant

Table 4. Influence of pulsing with sucrose (10 per cent) + $\text{Al}_2(\text{SO}_4)_3$ (250 ppm) followed by duration of dry cool storage (4–5°C) on floret opening and quality of tuberose spikes cv. Mexican Single

Storage days	No. of florets fully opened	No. of florets half opened	No. of pair unopened	Diameter (cm)	1st floret pair		3rd floret pair		last opened floret pair	
					Length (cm)	Diameter (cm)	Length (cm)	Diameter (cm)	Length (cm)	Diameter (cm)
3	23.50	5.60	13.40	4.01	7.20	3.95	7.00	3.89	6.70	
4	20.20	7.20	12.80	3.95	7.12	3.89	6.97	3.84	6.43	
5	18.30	7.80	15.60	3.93	7.00	3.85	6.92	3.82	6.21	
6	16.20	8.90	15.40	3.91	6.89	3.81	6.81	3.79	6.12	
Control ^a	11.00	9.20	27.10	3.73	6.50	3.61	6.47	3.53	5.97	
SEm ±	0.57	0.24	0.50	0.08	0.20	0.09	0.17	0.11	0.15	
F test	**	**	**	NS	**	**	NS	NS	**	
CD at 5%	1.80	0.77	1.58	0.28	0.63	0.28	0.54	0.37	0.49	

^a Cut spikes neither pulsed nor stored

** Highly significant, NS - Non significant

**INFLUENCE OF PULSING FOLLOWED BY DURATION OF
DRY COOL STORAGE ON CUT SPIKES OF TUBEROSE
(*POLIANTHES TUBEROSA* L.) cv. DOUBLE**

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ABSTRACT

An experiment was conducted to study the effect of pulsing with two different chemicals followed by duration of dry cool storage on cut spikes of tuberose cv. Double. A pulse treatment of sucrose (8 per cent) + CaCl_2 (500 ppm) for 24 hours and ZnSO_4 (7.5 mM) for 6 hours were applied to cut spikes of tuberose, which were then dry cool stored at low temperature (4–5° C) for 4 and 5 days, respectively. Pulsing with sucrose (8 per cent) + CaCl_2 (500 ppm) for 24 hours was best in respect to increased rachis length, delay in wilting of first, third and last opened floret pair, extension of useful life, retention of fragrance, water uptake, opening of florets, increase in diameter and length of first, third and last opened floret pair, and vase life in comparison to unpulsed spikes, whether or not stored. Maximum vase life of 8.2 days after 4 days dry cool storage was observed after a pulse treatment of sucrose (8 per cent) + CaCl_2 (500 ppm) for 24 hours.

INTRODUCTION

Among the ornamental bulbous plants, tuberose (*Polianthes tuberosa* L.) occupies a very selective and special position. It is commercially used for cut flower production and essential oil extraction. Flowers are perishable in nature and therefore need to be treated with suitable chemical preservatives to increase postharvest life and to extend their availability period. An investigation was undertaken to study the effect of pulsing and low temperature (4–5° C) on vase life and quality of cut spikes of tuberose cv. Double.

MATERIALS AND METHODS

The present investigation was carried out during July–September 2001 by procuring tuberose spikes from the research plot of the All India Coordinated Research Project on Floriculture, Indian Agricultural Research

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Institute, New Delhi-110012. The cut spikes were harvested in the morning between 7–8 AM at a stage when lowermost two basal florets were fully opened. These were transferred immediately to a bucket containing freshly collected tap water and taken to the laboratory. The spikes were cut to a length of 60 cm. After pulsing, the cut spikes were packed in polyethylene bags (70 cm x 40 cm) of 80-gauge thickness. The open end of each bag was folded twice and then stapled. The bags were punched uniformly for ventilation. Five spikes were packed in each bag and immediately transferred to cold storage. After storage for 4 and 5 days, respectively, the spikes were removed from the bags and placed in uniform size bottles (500 ml) containing 300 ml of tap water. One set of cut spikes was not pulsed but kept in cold storage for 4 and 5 days, while another set of cut spikes was neither pulsed nor stored but kept in tap water (control). For each pulsing treatment separate experiments were conducted in the laboratory in completely randomized design. There were altogether five treatments for each experiment replicated four times and five cut spikes were taken for each replication. Vase life evaluation of the cut spikes was carried out in the laboratory under ambient temperature (25° C). Useful life was recorded from the time of placement in vase to the point when maximum basal florets remained fresh. The cut spikes kept in bottles containing tap water were observed daily for senescence and the total period of vase life was noted in days. The end of useful vase life of cut spikes was marked either by wilting of florets or by other visual symptoms like browning, dropping of florets or drying up of outer petals. The total number of days until half of the florets on a spike wilted was recorded as vase life.

RESULTS

INFLUENCE OF PULSING WITH SUCROSE (8 PER CENT) + CaCl_2 (500 PPM) FOR 24 HOURS FOLLOWED BY DURATION OF DRY COOL STORAGE (4–5° C) ON FLORET QUALITY AND VASE LIFE OF TUBEROSE SPIKES CV. DOUBLE

Perusal of data in Table 1 indicates that pulsing with sucrose (8 per cent) + CaCl_2 (500 ppm) and cool storage significantly affected the rachis length; wilting of the first, third and last opened floret pair; useful life; fragrance; water uptake and vase life of cut spikes of tuberose. Pulsed cut spikes stored dry and cool for 4 days showed significant increase in rachis length (3.57 cm) over unpulsed stored spikes and control. The second best treatment was pulsed spikes stored for 5 days (3.4 cm). Pulsed spikes stored for 4 days had

maximum freshness of the first floret pair (2.30 days), third floret pair (3.20 days) and last opened floret pair (5.10 days). Useful life (2.70 days) and fragrance (2.80 days) was also maximized by pulsing with 4 days dry cool storage. Maximum water uptake (47.00 ml) was recorded after 4 days of dry cool storage. Maximum vase life (8.20 days) of tuberose spikes occurred with pulsed spikes stored dry and cool for 4 days, while minimum vase life (3.40 days) was observed in unpulsed spikes stored dry and cool for 5 days.

INFLUENCE OF PULSING WITH SUCROSE (8 PER CENT) + CaCl_2 (500 PPM) FOR 24 HOURS FOLLOWED BY DURATION OF DRY COOL STORAGE (4–5° C) ON FLORET OPENING AND QUALITY OF TUBEROSE SPIKES CV. DOUBLE

It is evident from Table 2 that pulsing with sucrose (8 per cent) + CaCl_2 (500 ppm) and dry cool storage significantly affected number of opened florets, half opened florets, unopened florets, diameter and length of third floret pair and length of the last opened floret pair. Maximum number of opened florets (16.70) was observed in pulsed spikes stored for 4 days, followed by pulsed flowers stored for 5 days (15.20). Maximum number of unopened florets (22.20) was recorded in unpulsed spikes stored dry and cool for 5 days. Maximum diameter (2.89 cm) and length (5.47 cm) of the third floret pair were found in pulsed spikes stored dry and cool for 4 days; however, no treatments (pulsed storage or unpulsed storage) affected diameter of the last opened floret pair. Maximum increase in length (5.01 cm) of the last opened floret pair was recorded in pulsed cut spikes stored for 4 days. Pulsing of tuberose cut spikes and storing them for 4 days at 4–5° C was found most beneficial in enhancing the floret opening and floret size over other treatments.

INFLUENCE OF PULSING WITH ZnSO_4 (7.5 mM) FOR 6 HOURS FOLLOWED BY DURATION OF DRY COOL STORAGE (4–5° C) ON FLORET QUALITY AND VASE LIFE OF TUBEROSE SPIKES CV. DOUBLE

The greatest increase in rachis length, water uptake, useful life, vase life, retention of fragrance and delay in the wilting of the last opened floret pair were recorded when cut spikes were pulsed with ZnSO_4 (7.5 mM) and dry cool stored for 4 days (Table 3). Maximum increase in rachis length (3.41 cm) was observed in pulsed cut spikes stored dry and cool for 4 days over the control (2.99 cm). In those cut spikes which were not pulsed but stored, an inhibition in rachis length occurred. After 4 days of dry and cool storage, pulsed spikes showed an increase in useful vase life (2.5 days) over the control (2 days).

Useful life of cut spikes decreased in unpulsed spikes stored dry and cool for 4 and 5 days (1.60 and 1.10 days, respectively). Maximum water uptake (44 ml) was recorded in pulsed cut spikes after 4 days of dry and cool storage (control = 39 ml). Vase life increased to 6.3 days in pulsed and stored spikes (control = 5.20 days). Decrease in vase life was observed in unpulsed but stored cut spikes. Pulsing with ZnSO_4 (7.5 mM) and storing the cut spikes for 4 days enhanced the useful life, vase life and rachis length of the cut spikes.

INFLUENCE OF PULSING WITH ZnSO_4 (7.5 mM) FOR 6 HOURS FOLLOWED BY DURATION OF DRY COOL STORAGE (4–5° C) ON FLORET OPENING AND QUALITY OF TUBEROSE SPIKES CV. DOUBLE

Pulsing of tuberose spikes with ZnSO_4 (7.5 mM) had significant effects on number of fully opened and half opened florets, diameter and length of third floret pair and length of last opened floret pair (Table 4). Maximum number of fully opened florets (15.3) was recorded in pulsed cut spikes dry cool stored for 4 days (control = 10.8). Inhibition of floret opening was observed in cut spikes which were not pulsed but stored. The minimum number of fully opened florets (6.4) was recorded in unpulsed spikes stored for 5 days. Maximum diameter and length of florets was recorded in pulsed spikes after 4 days of dry and cool storage. Floret opening, diameter and length of florets were enhanced by pulsing and storage for 4 days.

DISCUSSION

Use of calcium has increased fresh weight of flowers and water uptake (Nagarajaiah and Reddy, 1991). Hong and Zhao (1998) reported that spray application of 0.5–2.0 per cent CaCl_2 extended the vase life of cut roses by 2 to 4 days. In 'Ariana' cut roses the addition of calcium salts in postharvest chemical treatment significantly improved the vase life (Bolwar et al., 1999). Baas et al. (2000) observed that in cut rose cvs. First Red, Escada and Mercedes, calcium treatment resulted in better quality flowers. Pulsing with CaCl_2 (1 per cent) for 20 hours improved the vase life and quality of cut 'Raktagandha' roses (Sankar Vidhya and Bhattacharjee, 2002). Significant improvement in the vase life of cut roses by using CaCl_2 has also been reported by other researchers (Torre et al., 1999; and Bhattacharjee et al., 2001). Calcium induced delay in petal senescence protecting membrane proteins and phospholipids from degradation, thus maintaining membrane stability (Hong and Zhao 1999), reducing ethylene production, and solute transport and tissue vitality (Torre et al., 1999).

In gladiolus, ZnSO_4 (0.5 mM) + Sucrose (4 per cent) significantly prolonged vase life over control (Murali and Reddy, 1993). Beneficial effects of ZnSO_4 in gladiolus were also reported by De et al. (1998). It is evident from our experiments that use of either chemical coupled with cool, dry storage has similar effects on tuberose.

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Table 1. Effect of pulsing with sucrose (8 per cent) + CaCl_2 (500 ppm) for 24 hours followed by duration of dry cool storage (4–5 °C) on floret quality and vase life of tuberose spikes cv. Double

Storage days	Increase in rachis length (cm)	Number of florets per spike	1st floret pair wilting (days)	3rd floret pair wilting (days)	Useful life (days)	Last opened floret pair wilting (days)	Fragrance (days)	Water uptake (ml)	Vase life (days)
4	3.57	37.90	2.30	3.20	2.70	5.10	2.80	47.00	8.20
5	3.40	35.70	2.10	3.00	2.30	4.70	2.60	44.00	7.70
4a	1.44	36.00	1.50	2.10	1.60	3.10	1.60	30.00	4.10
5a	1.01	37.30	1.20	1.82	1.10	2.20	1.20	23.00	3.40
Control ^b	2.99	37.20	2.00	2.96	2.00	3.50	2.10	40.00	5.20
SEm ±	0.08	1.08	0.05	0.06	0.06	0.12	0.06	1.17	0.17
F test	**	NS	**	**	**	**	**	**	**
CD at 5%	0.26	3.40	0.16	0.21	0.21	0.38	0.21	3.71	0.54

^a Cut spikes not pulsed but stored^b Cut spikes neither pulsed nor stored

** Highly significant, NS - Non significant

Table 2. Effect of pulsing with sucrose (8 per cent) + CaCl_2 (500 ppm) for 24 hours followed by duration of dry cool storage (4–5 °C) on floret opening and quality of tuberose spikes cv. Double

Storage days	No. of florets fully opened	No. of florets half opened	No. of pair unopened	Diameter (cm)	1st floret pair		3rd floret pair		last opened floret pair	
					Length (cm)	Diameter (cm)	Length (cm)	Diameter (cm)	Length (cm)	Diameter (cm)
4	16.70	7.90	13.30	3.02	5.49	2.89	5.47	1.99	5.01	
5	15.20	8.10	12.40	2.99	5.39	2.81	5.45	1.91	4.96	
4a	7.20	7.40	21.40	2.81	5.00	2.45	4.72	1.78	4.49	
5a	6.40	8.70	22.20	2.69	4.93	2.37	4.65	1.61	4.38	
Control ^b	10.80	5.60	20.80	2.88	5.03	2.51	4.81	1.85	4.52	
SEm ±	0.29	0.24	0.34	0.12	0.18	0.08	0.14	0.05	0.14	
F test	**	**	**	NS	NS	*	**	NS *		
CD at 5%	0.93	0.75	1.08	0.38	0.56	0.25	0.46	0.15	0.46	

^a Cut spikes not pulsed but stored^b Cut spikes neither pulsed nor stored

* Significant at 5%, ** Highly significant, NS - Non significant

Table 3. Effect of pulsing with ZnSO_4 (7.5 mM) for 6 hours followed by duration of dry cool storage (4–5 °C) on floret quality and vase life of tuberose spikes cv. Double

Storage days	Increase in rachis length (cm)	Number of florets per spike	1st floret pair wilting (days)	3rd floret pair wilting (days)	Useful life (days)	Last opened floret pair wilting (days)	Fragrance (days)	Water uptake (ml)	Vase life (days)
4	3.41	38.20	2.00	2.90	2.50	4.60	2.70	44.00	6.30
5	3.37	36.50	1.90	2.70	2.30	4.40	2.30	43.00	5.80
4 ^a	1.44	36.00	1.50	2.10	1.60	3.10	1.60	30.00	4.10
5 ^a	1.01	37.30	1.20	1.82	1.10	2.20	1.20	23.00	3.40
Control ^b	2.99	37.20	2.00	2.90	2.00	3.50	2.10	39.00	5.20
SEm ±	0.09	1.03	0.04	0.06	0.04	0.09	0.05	0.77	0.10
F test	**	NS	NS	NS	**	**	*	**	**
CD at 5%	0.28	3.24	0.13	0.20	0.15	0.28	0.16	2.44	0.32

^a Cut spikes not pulsed but stored^b Cut spikes neither pulsed nor stored

* Significant at 5%, ** Highly significant, NS - Non significant

Table 4. Effect of pulsing with ZnSO_4 (7.5 mM) for 6 hours followed by duration of dry cool storage (4–5 °C) on floret opening and quality of tuberose spikes cv. Double

Storage days	No. of florets fully opened	No. of florets half opened	No. of pair unopened	Diameter (cm)	1st floret pair		3rd floret pair		last opened floret pair	
					Length (cm)	Diameter (cm)	Length (cm)	Diameter (cm)	Length (cm)	Diameter (cm)
4	15.30	9.20	13.70	3.01	5.41	2.82	5.40	1.93	4.99	
5	16.20	7.10	13.20	2.99	5.40	2.80	5.37	1.92	4.95	
4 ^a	7.20	7.40	21.40	2.81	5.00	2.45	4.72	1.78	4.49	
5 ^a	6.40	8.70	22.20	2.69	4.93	2.37	4.65	1.61	4.38	
Control ^b	10.80	5.60	20.80	2.88	5.03	2.51	4.81	1.85	4.52	
SEm ±	0.33	0.19	0.47	0.07	0.13	0.05	0.12	0.04	0.10	
F test	**	**	NS	NS	NS	**	**	NS	**	
CD at 5%	1.04	0.60	1.50	0.24	0.40	0.17	0.39	0.14	0.31	

^a Cut spikes not pulsed but stored^b Cut spikes neither pulsed nor stored

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NOTES ON *ERANTHIS* AND *ANEMONE*

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Bulbs and corms often grow at locations with warm dry summer conditions and low temperatures at wintertime. Growing and flowering season may be restricted to a few weeks and limited by water supply (both rainfall and/or melting snow) and temperature. The early spring flowering bulbous *Eranthis* and *Anemone blanda* (Ranunculaceae) represent an example of competition in this habitat. Both plants grow and flower naturally at nearly the same time on stony slopes of the coastal mountains at Turkey at an altitude of about 800–1500 m. They maintain themselves during the warm, dry summer by unrooted corms. However, with the onset of rainfall in autumn, temperature seem to become important for further development.

The first step after water-uptake by the corms is induction and growth of roots. Some experiments with dry corms, planted in pots and cultivated at different constant temperatures (Zimmer and Girmen, 1987), indicated that *Anemone blanda* will root at higher temperatures, whereas low temperatures (5° C) will delay root growth (Table 1). *Eranthis*, however, did not produce roots within 14 weeks at 17°C, but rooted well at 5°C. Under natural conditions, therefore, *Anemone* starts rooting with the higher soil temperatures at



Fig. 1. *Erantnis hiemalis* and *Anemone blanda* between rocks on stony slopes.



Fig. 2. *Anemone blanda* and *Gagea* sp. at the same habitat, about 1200 m, near Akseli, Turkey.



Fig. 3. In small basins, inclined to the north, *Eranthis hiemalis* will flower in melting snow.

the end of summer coupled with the first rainfalls. *Eranthis* starts rooting about four weeks later than *Anemone* at 5° C. Rooting of *Eranthis* therefore may begin in spring during snowmelt with low soil temperatures, and not in autumn, when precipitation changes from rain to snow.

The second step is the production of buds, leaves and/or flowers. In dry corms, buds are not visible, becoming so about four weeks after planting. Measuring the length of visible bud again indicated that temperature is an important factor for further development of both *Anemone* and *Eranthis*. Although no dissections were made, it was clear that leaves and flowers were differentiated during the period of elongation. In both plants, low temperature is essential for growth and flowering. At 17° C, buds of *Anemone* grew slowly, and within 14 weeks the bud developed into a "dome" about 4–6 mm in height (Table 2). At 5°C, however, elongation occurred more rapidly after 8–10 weeks. *Eranthis* did not develop leaves or flowers at 17° C, but the lower the temperature the stronger the elongation of organs.

It is clear therefore, that both *Anemone blanda* and *Eranthis* have a low-temperature requirement for sprouting and flowering and this will result in nearly the same flowering time under natural conditions.

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Table 1. Root length (mm) of *Anemone blanda* and *Eranthis cilicica* planted at different temperatures. Average of 30 or 40 corms.

Weeks after planting at	<i>ANEMONE</i>		<i>ERANTHIS</i>	
	17° C	5° C	17° C	5° C
2	0	1	0	1
4	44	5	0	1
6	98	22	0	7
8	101	25	0	14
10	146	72	0	43
12		93	0	65

Table 2. Length of bud or leaf/flower/ of *Anemone blanda* and *Eranthis cilicica* planted at different temperatures. Average of 30 or 40 corms.

Weeks after planting at	<i>ANEMONE</i>		<i>ERANTHIS</i>	
	17° C	5° C	17° C	5° C
2	0	0	1*	1
4	2	2	1	2
6	3	3	1	3
8	3	4	1	4
10	6	17	1	6
12	4	18	1	7
14	4	33	1	8

* nearly 1 mm swollen bud during 14 weeks

MASSONIA PUSTULATA — A CURIOSITY?

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The genus *Massonia* is one of the less known groups of bulbous plants from South Africa. Following Bryan (1989), the plants are "unusual, not of great merit and suitable only for those much interested in bulbs". The genus belongs to the Hyacinthaceae, although the flower umbels look like those of *Haemanthus*. Some of the bulbous species were introduced to Europe as early as 1775 and mentioned in *Miller's Dictionary of Gardening* in 1790. During the following two hundred years, the plant was repeatedly described (e. g., Curtis's Bot. Mag. t. 642, 1803; Gardener's Chronicle Ser. III, 1906). Recently some notes were found on *Massonia pustulata* under the aspect of introduction of new interesting plants (van Meggelen-Laagland, 1994; Schlesies, 1995). Bulbs have been offered commercially as a rarity at rather exorbitant prices.

It is said that the plant "requires warm greenhouse conditions" and that "they must be given a dry and warm resting period" (Bryan, 1989). The assumed demand for a summer rest period was the reason for our interest in using the plant for studies of flower induction as well as attempts to overcome the rest period or dormancy. For this purpose, we tried to develop a propagation method, starting with 26 seeds and four bulbs, which we obtained by courtesy of Mr. Schlesies who had published his experiences with this plant in two German journals. He also mentioned the need for a "rest-period, which should be observed strictly" (Schlesies, 1995).

For scientific experiments it is essential to use uniform material, thus it is often desirable to use clones (i.e., genetically identical material). Therefore, we tried to develop clones from our 26 seeds. After sterilization in the usual way they were sown on sterile Murashige and Skoog medium without any plant hormones added. At 20° C and 16 hours of artificial light, seeds germinated (20 of 26) within four weeks. Under the same conditions they produced small bulbs of about 1 cm in diameter within one year. Multiple shoot formation from one germinating seed was not observed, perhaps due to the lack of plant hormones in the medium.

This *in vitro* grown seedlings were used to produce clones. The small bulbs were divided into four parts and grown on a medium with plant hormones. We used the Murashige and Skoog multiplication medium to obtain



Fig. 1. *Massonia pustulata*



Fig. 2. Explant (1/4 bulb) after 6-week-period on M & S medium including cytokinine BAP and two, 6-week periods on M & S medium without BAP.



Fig. 3. One year old *in vitro* grown plantlet. Note the spirally twisted roots.

enough plants for our studies of the effects of cytokinines, light and sugars on multiplication rate. Some results are presented from our original paper (Zimmer and Krause, 2000).

One of our most important findings was that under *in vitro* conditions at 22° C day and night, with 16 hours of artificial light, no rest period or dormancy was observed. Explants grew continuously, although vigor of the different clones (genotypes) was variable. Vigor may be expressed in terms of number of regenerated sprouts per explant and time. Therefore, we selected from our 20 clones three groups of clones with differing vigor or regeneration ability

(Table 1), based on a running regeneration system and more than one 6-week cycle.

Regeneration of shoots depends on cytokinines, plant hormones which regulate production of new meristematic cells from the storage cells of the bulb scales. For our experiments we used a quarter of a small bulb about 1 cm in diameter. These “quarters” were induced during one 6-week period on an M & S-medium including the cytokinine benzyl amino-purine (BAP) and then grown for two 6-weeks cycles on BAP-free medium. Some typical results are shown in Table 2.

Doubling the “induction period” on medium containing BAP may increase the number of shoots per explant. One of our clones with low production rate (Table 1) increased the number of shoots from nearly 5 per bulb to about 12 per bulb, while another genotype with high production rate increased the number of shoots from 18 per bulb to 69 per bulb.

After separation, single shoots need about two or three months before bulb formation *in vitro*. This process is strongly influenced by light and

sugar concentration in the medium (Table 3). Increasing both light intensity or light amount and sugar concentration raises carbohydrate concentration in the plantlets, which results in greater bulb formation.

The primary aim of our propagation experiments was to obtain large numbers of genetically identical bulbs for our research on induction and overcoming of "dormancy." Under *in vitro* conditions, however, we never found resting or dormant plants. The reason for this may be the availability of cytokinines in the medium and the plantlets. We may conclude this from results with *Dodecatheon meadia* (Primulaceae), in which the cold requirement for breaking bud dormancy can be substituted for by applying the cytokinin BAP (Bebler and Zimmer, 1994).

Our four bulbs, obtained at the beginning of our seed propagation experiments were planted in a sandy soil. They grew out rapidly at 20–22° C in a greenhouse. Within 8 weeks after planting in early September, inflorescences were developed between the dark green, glossy, and pustulate leaves. During winter, flowering occurred and cross-pollination resulted in fruit and seed production. During the period of fruit ripening, new leaves were produced and the original leaves began to shrivel. The plants grew continuously and flowered again within one year after planting.

In vitro grown plantlets transferred to greenhouse conditions, as well as seedlings, grew well and flowered freely without any rest period. We have grown thousands of *in vitro* propagated plants under artificial light (16 hours, about 300 foot candles of Mercury-light, 20–22° C) continuously for two years and have never observed any rest period. These results indicate that, under natural conditions, the combination of very high soil temperature with drought produces a cessation of growth and root death. Without growing root tips, the plant cannot produce cytokinines. Thus the rest period of *Massonia pustulata* is induced exclusively by the climatic conditions of its natural habitat, rather than any intrinsic physiological demand on the part of the plant.

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Table 1. Regeneration rate of *Massonia pustulata* genotypes.

No of genotypes	Shoot production	No. of shoots/ bulb	No. of 6-week cycles
4	low	5.6	1.8
4	medium	10.8	0.5
4	high	17.9	2.5

Table 2. Effect of cytokinine BAP on number of plantlets of *Massonia pustulata*.

No. of explants	BAP, mg/L	Average number of plants per explant
74	0	3.0
77	1	4.5
78	2	6.4

Table 3. Influence of light and sugar concentration on bulb formation, % plants with bulbs after 12 week growing period.

Light Treatment	Sugar concentration, g/l		
	0	20	40
Darkness	4	29	41
8 hrs, 300 ft.-cand.	27	39	57
16 hrs, 300 ft.-cand.	43	71	79



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BOOK REVIEWS



Wild Lilies, Irises, and Grasses. *Gardening with California Monocots.* Edited by Nora Harlow and Kristin Jakob. Illustrations by Kristin Jakob. The University of California Press. 287 pages, 7" x 9-1/4", Hardcover \$50.00, ISBN 0-520-23848-6

California enjoys a rich diversity of monocots (and other plants) thanks to the great variety of habitats: from the fog belt to deserts, from coastal plain to mountain, chaparral, grassland and forest (oak, pine or redwood). Monocot species can be found everywhere, adapted to local conditions, and many of these may be suitable for garden use. Some have showy flowers or attractive leaves, while others—particularly the grasses, succulents and palms—will contribute architectural interest to the garden.

The authors present descriptions and cultural requirements for around 250 of the more notable California species, illustrated with 58 color photographs and 74 attractive line drawings. Some of the plants are available in local nurseries, while others may be located through seed exchanges and specialist catalogs. Rare and endangered species are discussed, and the reader is warned against collecting them from the wild. Sources are listed, along with display gardens in the state and various plant societies that may offer seed and plant exchanges.

There is a brief discussion of different approaches to taxonomy—such as “lumping” vs. “splitting”, Linnaean vs. lineagics—but the authors wisely avoid the controversies by grouping plants according to horticulture considerations. “Species names are consistent with those cited in the University of California, Berkeley, Jepson Flora Project’s Online Interchange for California Floristics” (<http://ucjeps.berkeley.edu/interchange.html>).

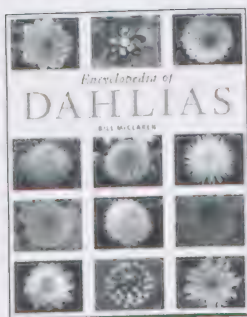
A convenient table lists the various plants with their cultural requirements, allowing the reader to begin selecting species that can be grown together, or in adjacent parts of the garden. A glossary is provided for those of us who can’t quite remember what cismontane, serpentine or mesophytic mean.

The emphasis throughout the book is on California plants for California gardens, but the various species of *Fritillaria*, *Allium*, *Lilium*, *Trillium*, *Calochortus*, *Dichelostemma*, *Brodiaea*, *Iris* and many others may appeal to gardeners, collectors and plant breeders in other states and countries who can provide suitable conditions in their gardens or greenhouses, or who may need the special adaptations of some unusual species for breeding purposes.

This is not a field guide to all the monocots of California. The plants have been selected and the information is arranged for the needs of gardeners, not botanists. As such it is a valuable contribution, and may serve as an inspiration for native plant enthusiasts everywhere.

At the time of this writing, Amazon.com is offering the paperback edition for \$16.97, a very reasonable price for such an excellent book.

Karl King
California



Encyclopaedia of Dahlias. Bill McClaren. Timber Press, Portland, OR, Cambridge, UK. Hardcover, 8.5" x 11", 211 pp, 855 color photos, 2 line drawings. \$39.95. ISBN 0-88192-658-2

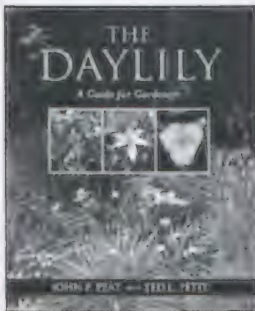
History relates that in the September I was born the family plot was resplendent with dahlias, and there are indeed few plants that produce such a magnificent show so reliably in the autumnal months. For most of my life, however, dahlias have been out of fashion, so far as the British gardening pundits were concerned: vulgar, bloated things only suited to those who grow their vegetable equivalents of lengthy leeks and monstrous marrows. In recent years, however, this snobbery has been diluted, and dahlias are beginning to reclaim their rightful place in the flower garden.

To those who have excluded dahlias from their life this book will come as a shock—I hope; the diehards may think it merely confirms their prejudices. The bulk of the *Encyclopaedia of Dahlias* is a catalogue of dahlias by class and color, superbly illustrated and succinctly described. It presents the full panoply of options, from the football-sized double monsters to most delicate singles, from flaunting scarlets to sultry maroons. The descriptions record a cultivar's origins and its American Dahlia Society classification before a brief note on its attributes. Most unusually, but most valuably, this includes the really practical information that comes from an expert who knows what he is talking about, in the form of a commentary on a plant's 'growability.' An example taken at random is the entry for 'Chilson's Pride' in which we learn that it is 'Easy to grow, tolerates heat, and produces excellent tubers that store well.' Further, we learn that it is a potential winner in several show classes and categories. Practical information comes also in the chapters concerning propagation and all aspects of *Dahlia* cultivation.

Encyclopaedia of Dahlias is essentially a guide to plants suitable for showing at shows organized by the American Dahlia Society. This it does very well, with the ADS classification scheme clearly explained and with notes on showing. This leads to the book's slight weaknesses, in that it discusses only show dahlias and omits those raised solely for bedding or cut-flower purposes, many of which are far better garden plants and more easily available in the retail trade than those used principally for showing. It is also aimed at the North American Dahlia scene, which is understandable, but limits its usage for us in Europe. A quick check of the first thirty cultivars to have received the Royal Horticultural Society's Award of Garden Merit (a most useful benchmark, sparingly given) reveals that only 3 are discussed in this book.

Bill McClaren should be proud of this book, obviously the product of a life-long fascination with its subject. In addition to being a mine of information it is attractively presented and most generously illustrated and I recommend it to anyone in the IBS who can accept a *Dahlia* as a genuine geophyte and a handsome plant for the garden.

John Grimshaw
United Kingdom



The Daylily, a Guide for Gardeners. John P. Peat and Ted L. Petit. 2004. Hardcover. 200 pp. 7" x 9" (230 x 180 mm); 197 color photos, 8 watercolors; ISBN: 0-88192-666-3.

With more than a thousand new daylilies registered each year, daylilies have become one of the most popular plants to grow, especially in the United States. Known and cultivated for over 2500 years by the Chinese for food and medicine, the genus *Hemerocallis* is still not well defined. Approximately 20 species, some with several varieties, range through China, Korea and Japan. Daylilies were first introduced into Europe where breeding programs were established in the mid-1850s. Once plants arrived in North America, hybridizers began a slow but steady increase in activity, initially using diploid plants. Daylily fever pitch reach its height in the period from 1950-1975, and the trend of breeding efforts shifted to tetraploid daylilies, due to their heavier substance and greater vegetative vigor.

To the typical and popular round, full-formed, single daylilies, hybridizers have added double daylilies of three sorts: “peony double,” formed by modified petaloid stamens; “hose-in-hose,” in which extra true petals have been added; and “polypetala” daylilies, in which every part of the flower has been increased (personally, I prefer daylilies that look like daylilies!). Breeders have also created small and miniature daylilies using the smaller statured and flowered species, as well as spider-flowered and other unusually formed flowers. All of this diversity has caused confusion and conflict in the American Horticultural Society *Hemerocallis* committee.

Daylilies are easily grown from seed, reaching blooming size in the first year under good conditions. They are beloved throughout the world for their carefree nature, and ability to adapt to a range of climates. Best in full sun (though tolerant of part shade), they thrive in moist but well drained soil, with even moisture and regular fertilization. At the same time they will tolerate heavy soils and are fairly drought tolerant. They are easily increased by division. Until the arrival of daylily rust fungus in America, *Hemerocallis* were considered virtually pest and disease resistant.

All of this information is contained in this new book, but it is by no means an exhaustive guide to every aspect of the genus. The sub-title, “A Guide for Gardeners,” explains the goal of the volume; it is a book for gardeners, rather than enthusiasts. Each chapter is rather short, written by the authors themselves or with others, and deals with species, landscaping, cultivation, pests and disease. In truth, each of these subjects could fill a book! The main feature of the book is a history of daylily hybridizing, this fashionable art developed in Europe, Australia, Canada but especially in the United States. This includes a display of the hybrids “that have had a significant impact on breeding programs, and that have won American Hemerocallis Society (AHS) awards” since the 1890’s. Two hundred fine images run through the book depicting hybrids, primarily created by the authors. An interesting list is presented of the award-winning daylilies since 1980 within various categories, many named after well known hybridizers (Stout, Munson, Giles, for example); these are unfortunately not illustrated. To their credit, the authors provide a list of daylily societies and world-wide sources of the plants. In short, this is a well executed introduction to the development of the modern daylily, and a good beginner’s guide to cultivation.

Alberto Grossi
Italy

CONTRIBUTOR'S GUIDELINES FOR *HERBERTIA*

HERBERTIA is an international journal devoted to the botany and horticulture of geophytic plants. A special emphasis of the journal is the Amaryllidaceae and other petaloid monocot families rich in bulbous or cormous plants, but articles treating any aspects of dicotyledenous geophytes are welcome as well. Contributors are asked to follow the following guidelines when submitting papers. Manuscripts departing grossly from this format will be returned to the author(s) for revision. PLEASE ALSO REFER TO A CURRENT ISSUE OF THE JOURNAL FOR FORMAT.

1. Articles in *HERBERTIA* may be refereed (peer-reviewed) or non-refereed. Articles of a scientific nature (e.g., taxonomy, plant physiology) will usually be sent to at least two appropriate reviewers. Authors wishing to insure that their contributions will be peer-reviewed should indicate so in their cover letters.
2. Manuscripts must be typed or produced with legible ink jet or laser printers on 8 1/2 x 11 inch paper. Double spacing should be used throughout.
3. An electronic copy of the manuscript MUST accompany the written copy. This should be provided on a diskette or send to the editor as an email attachment. Microsoft Word for Windows versions 6, 7, 97, 2000 and XP are preferred, but WordPerfect, Word for the Macintosh, or other standard word processors are acceptable.
4. Scientific papers may be prefaced with a short abstract if appropriate and so desired.
5. Descriptions of taxa must follow conventional form as to construction of descriptive paragraphs, specimen citation, and synonymy. Use the following example as a guide or consult journals such as *Systematic Botany*, *Brittonia*, or *Annals of the Missouri Botanical Garden*:

Eucrosia aurantiaca (Baker) Pax. Die Nat. Pflanzenfam. (A. Engler and K. Prantl, eds.), 15a: 415 (1930).

Callipsyche aurantiaca Baker. Refug. Bot. 3:t. 167 (1869). Neotype: Ecuador, El Oro, Ayabamba, 200 m, Andre 4262 (K).

Eucrosia morleyana Rose. Addisonia 7: 3-4, pl. 226 (1922). Type: Ecuador, Chimborazo, Huigra, 4000 ft, Rose & Rose 22593 (holotype, US; isotypes, GH, NY, S).

Eucrosia eucrosioides var. *rauhiana* (Traub) Traub. Pl. Life 22: 62 (1966).
Callipsyche eucrosioides var. *rauhiana* Traub. Pl. Life 13: 61 (1957). Type:
 Ecuador, Azuay, Pasaje, 300 m, Rauh & Hirsch E15 (holotype, MO)

Bulb large, 7.7–10 cm long, 6–7.7 cm in diam.; tunics tan-brown; neck (2.5)5–8 cm long, 2–2.6 cm thick. Leaves 2, hysteranthous; petiole 27–35 cm long, 7.5–10 mm thick, deeply channelled for most of its length; lamina ovate-elliptic, 29–40 (50) cm long, (12) 16–22 (29) cm wide, acute or short-acuminate, basally attenuate to the petiole, thick, coarsely undulate, hypostomatic, abaxial cuticle thickly striate and non-glaucous. Scape (5) 7–9(10) dm tall, ca. 10 mm in diam. proximally, ca. 4–6 mm in diam. distally; bracts 3(5) cm long, lanceolate. Flowers (7) 10–12 (13), zygomorphic, all reaching anthesis concurrently, more or less perpendicular to the axis of the scape; pedicels (11) 22–33 mm long, 1–2 mm in diam.; perianth (2.8) 3–4 (4.4) cm long, green in bud, yellow at anthesis, rarely orange or pink, compressed laterally giving the perianth a somewhat flattened appearance; tube sub-cylindrical, 5–7 mm long, ca. 5–6 mm wide, constricted at the ovary to ca. 3.8 mm wide, concolorous with the tepals for most of its length, green only at the base; tepals spreading dorsally and ventrally to 23–29 mm wide, recurved and sometimes stained green apically; outer tepals (20) 23–29 (36) mm long, 5–6 mm wide, apiculate, lanceolate, keeled, 2 of them situated laterally, one dorsally; inner tepals 20–26 (34) mm long, obtuse, oblanceolate-spatulate, margins undulate at the middle, 2 of them ca. 9.5 mm wide and situated laterally above the 2 lateral outer tepals, the third one 5–7 mm wide, ventrally declinate and with the lower lateral tepals forming a pseudo-labellum. Stamens subequal, 8.5–11 cm long, filiform, long-declinate, ascendent in their distal 1/4, green; filaments dilated and connate in their proximal 2–3 mm; globose nectar glands present at the perianth throat, each 1–2 mm in diam.; anthers 5.5–6 mm long, oblong; pollen green, the exine mostly tectate-perforate. Style 10–11 cm long, green; stigma less than 1 mm wide. Ovary ellipsoid, 6.5–9 mm long, 4–4.5 mm wide; ovules 20 or more per locule. Capsule 2.5–3 cm long, 17–22 mm in diam.; pedicel 5–6 cm long; seeds numerous, blackish-brown, ca. 6.5 mm long, 1.5 cm wide. $2n = 46$. Flowering July–September and December–January.

ECUADOR. El Oro: between Santa Rosa and La Chorita, 0–100 m, Hitchcock 21139 (GH, NY, US). Chimborazo: Río Chanchan canyon between Naranjapata and Olimpo, terrestrial in rock wall crevices, 800

- m, (ex hort), Horich ISI # 214 (UC). Between Huigra and Naranjapata, 600–1200 m, Hitchcock 20638 (GH, NY, US). Cañar: valley of Río Cañar near Rosario, 960 m, Prieto CP-18 (NY, S). Azuay: Road from Jiron to Pasaje, near Uzhcurrumi, dry, steep, rocky hillside, 840 m, Plowman et al. 4600 (GH), Plowman 7634 (F), Plowman 12024 (F). Km 97 on road from Cuenca to Saraguro, dry thorn scrub, ca. 1100 m [incorrectly typed on specimen label as 2400 m], Madison et al. 7517 (SEL). —Inhabiting semi-desert and dry, rocky canyons and hills of the lower inter-Andean valleys (100) 300–900 (1100) m. Endemic.
6. Descriptions of new taxa MUST be accompanied by a short Latin diagnosis or description. Holotype or isotype specimen MUST be deposited in an herbarium listed in the current edition of *Index Herbariorum*. A diagnostic drawing or photo documentation sufficient to distinguish the new taxon MUST accompany the text.
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Stebbins, G. L. 1984. Mosaic evolution, mosaic selection and angiosperm phylogeny. *Botanical Journal of the Linnean Society* 88: 149–164.

Book Chapter:

Hammen, T. van der. 1979. History of the flora, vegetation and climate in the Colombian Cordillera Oriental during the last five million years. Pp. 25–32 *in* H. Larsen & L. B. Holm-Nielsen (eds.). *Tropical Botany*. Academic Press, London.

Book:

Prance, G. T. (ed.) 1982. *Biological Diversity in the Tropics*. Columbia University Press, New York.

9. Figures accompanying contributions may be good quality line drawings, 35 mm transparencies, or high quality black and white or color photographs. Electronic format for figures is encouraged. Electronic copies of figures should be sent in uncompressed TIF format. Color or gray scale photos should be scanned at 1000 dpi; line drawings at 1200. Figure captions should be included in the manuscript following the literature citations.
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